A SYSTEM OF SURGERY

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A SYSTEM OF SURGERY

THE FEMALE GENITAL TRACT

BY VICTOR BONNEY, M.S., M.D., B.Sc., F.R.C.S.

History.—Note should be taken of the patient's age, her symptoms and their duration, the dates of any pregnancies, the frequency and duration of the menses and *the date of the last one.*

If pain be present, its position and its relation to posture and to the menstrual period should be ascertained. It cannot be gainsaid that one question asked after the physical examination is worth ten asked before it.

Examination in the consulting-room is best conducted with the patient lying in an attitude midway between the dorsal and the lateral positions, but with the shoulders more horizontal than the hips, so that the trunk is somewhat twisted at the waist. This position allows the examiner to apply his weight through his left hand on the patient's abdomen, and materially facilitates bimanual examination. Vaginal examination should be made with one finger, as two may cause pain, and is assisted by turning the patient during its performance, first into the semi-prone and then into the semi-supine position By this manœuvre the quadrants of the pelvis are successively rendered more accessible.

In bimanual examination, palpation must be chiefly conducted by the hand on the abdomen, the finger in the vagina being held stationary on the cervix or vaginal vault. Displacements like prolapse or retroversion should be investigated with the patient standing erect.

Rectal examination is often useful, especially in virgins. The tyro must be careful not to mistake the projection of the vaginal cervix for a tumour in front of the rectum.

The speculum.—An expert can distinguish almost all diseases of the vagina and vaginal cervix by touch alone, and therefore can usually spare his patient the discomfort of examination by speculum. Fergusson's speculum is easy to introduce, but shuts up the lips of a lacerated cervix, and fails to demonstrate the condition of the cervical

canal. Sims's speculum in a narrow vagina may fail to show the cervix well. The hinged bivalve speculum is better for consulting-room use.

The uterine sound.—This instrument is much less employed than formerly. The direction of the uterus can be estimated by bimanual examination, while the measurement of the length of the cavity is of doubtful utility, for great enlargement is obvious by other means, and small alterations in length (an inch or less), as revealed by the sound passed without anæsthesia, are often due to the point of the instrument deviating into a cornu.

The habitual use of the sound in the consulting-room will result sooner or later in its passage into a pregnant uterus by mistake. Cases undiagnosable by bimanual examination should be examined under an anæsthetic and the sound passed then.

Examination under anæsthesia is advisable when serious symptoms are present and diagnosis by ordinary examination is obscure. The lithotomy position is the right one for this purpose.

THE VULVA

DEFORMITIES AND DISPLACEMENTS

PSEUDO-HERMAPHRODITISM

Congenital malformations of the vulva are rare. The commonest is that seen in a pseudo-hermaphrodite hypospadiac male. This subject is discussed on p. 1017, Vol. II.

PROLAPSE OF THE URETHRA

Prolapse of the urethral mucosa occurs in elderly women. The protrusion is purple-red in colour, with a central aperture, and may be much inflamed or ulcerated, or even in a state of black sphacelus. The patient complains of a very tender swelling and of difficulty and pain in micturition. The central orifice in the swelling differentiates it from new growths in this situation. The redundant mucosa should be amputated circularly and the cut edge of the urethra united to the surface by fine catgut sutures. Care must be taken not to remove the mucous membrane of the vestibule, but to limit the excision to that belonging to the canal, otherwise stenosis may occur.

URETHROCELE

A urethrocele is a protrusion consisting of the lower inch of the anterior vaginal wall, and containing a pouched portion of the urethra. The condition is rarely met with, and the perineum is usually deficient. The patient is conscious of a lump which protrudes on

standing or straining. After the expulsive act of micturition, dribbling occurs as the distended pouch empties itself.

Treatment consists in excision of the redundant portion of the vaginal wall, together with the prolonged portion of the urethra, followed by closure of the openings in the walls of the canals by separate rows of sutures. Perineoplasty is then performed to prevent recurrence.

RUPTURE OF THE PERINEUM

Rupture of the perineum is either complete or incomplete, according to whether the tear involves the sphincter ani or not. In the first case, incontinence of fæces and flatus results, whilst in both the supporting mechanism of the lower genital canal is much weakened. This weakening, however, is due less to the actual tear than to the stretched condition of the levator ani muscles and other components of the lower segment of the supporting apparatus (*see* p. 17). The symptoms caused by an ununited tear of the perineum are therefore those of prolapse of the vagina (p. 23). The method of restoring the perineum in incomplete rupture is as follows: A flap of the posterior vaginal wall is dissected up and cut away in a V-shape. The V is then sutured, beginning at the apex above and ending where the most posterior of the carunculæ myrtiformes on either side mark the original boundary of the vaginal orifice. The edges of the levatores are now united by several catgut sutures, and superficial to them the edges of Colles's fascia are similarly joined, and finally the skin edges are brought together by a continuous suture. In complete rupture the steps are the same, except that, after turning up the vaginal flap, the deficiency in the anterior rectal wall is made good by sutures carried down until the natural shape of the anus is restored.

INFLAMMATION

SUBURETHRAL ABSCESS

Infection of one of the posterior urethral crypts may lead to an acute abscess. The pus usually discharges into the urethra, but sometimes finds an outlet on the vaginal surface and a sinus may result. Such an abscess may become chronic and eventually be converted into a suburethral cyst.

Treatment.—The abscess should be opened.

STREPTOCOCCAL AND PNEUMOCOCCAL VULVITIS

Infection with the streptococcus or pneumococcus may be primary after wounds, surgical operations, and labour; occasionally it is a secondary infection added to previous lesions, notably soft chancres and syphilis.

When the infection is virulent the type may be erysipelatous with much brawny swelling, or gangrenous, especially in debilitated children (*noma vulvæ*). In secondarily infected venereal sores the inflammation may be most destructive, and terminate in wholesale sloughing of the external genitals (*phagedænic vulvitis*). In the slighter cases there is simply reddening and soreness of the parts. Streptococcal vulvitis may accompany infection of the vagina by the same organism. Streptococcal cystitis often coexists in these cases.

Treatment.—Antiseptic fomentations should be applied, stitches removed from operation wounds, and constitutional symptoms met by the injection of an appropriate antitoxic serum, or vaccine. In the rare form of phagedænic inflammation the necrotic tissue should be scraped away with a sharp spoon and the parts well swabbed over with pure carbolic acid.

STAPHYLOCOCCAL VULVITIS (SIMPLE VULVITIS)

Simple vulvitis may occur after any wound of the vulva, or may be due to the irritation of scratching (*pruritus vulvæ*), diabetic urine, ichorous vaginal discharge, rough diapers, or masturbation. The surface is red, sore, and excoriated. In many cases it is associated with vaginitis, as in the vulvo-vaginitis of little children. Antiseptic fomentations and lotions are usually sufficient, combined with the removal of any discoverable cause. In young children vulvitis cannot be cured until the vaginitis is well. These cases are of medico-legal importance, and the pus should be carefully examined for evidence of venereal infection. (*See* Vaginitis, p. 12.)

GONOCOCCAL VULVITIS

Acute gonorrhœa in the female consists of a coincident inflammation of the vaginal cervix, vagina and vulva (*cervico-vagino-vulvitis*). The subject is discussed in Vol. I., pp. 866–69. Owing to the resistant nature of the vulval tissues the inflammation may have entirely subsided in them while still active in the vagina and cervix.

OTHER VENEREAL AFFECTIONS OF THE VULVA

The typical *hard chancre* is rarely met with on the vulva. Instead, the sores are multiple, ulcerative, or sometimes warty. With these is associated much swelling of the labia minora due to lymphangitis, which often hinders a satisfactory view of the parts. Inspection alone will generally fail to determine whether the lesion is syphilitic or merely chancroidal, especially as the two conditions may coincide. In either case the venereal element may be much accentuated by secondary infection with pyogenetic or necrogenetic organisms, leading to great destruction of the parts.

In the *secondary* period of syphilis various manifestations may

appear on the vulva, usually taking the form of superficial ulcerations with elevated warty edges. The initial swelling of the labia minora due to lymphangitis may persist, and result in an elephantoid hypertrophy.

Tertiary lesions are rare on the vulva, but when occurring take the form of gummatous masses which by their subsequent changes may occasion much deformity.

Venereal warts, though commonly known as "gonorrhœal," are not due to the gonococcus. They may occur without gonorrhœa, and occasionally in situations other than the vulva (e.g. the umbilicus). Microscopically they are papillomas. They are multiple, grow rapidly, and may attain an enormous size, the surface resembling that of a cauliflower. They emit a foul odour and a serous discharge.

Treatment.—Salvarsan, its congeners, and mercury should not, as a rule, be administered until the diagnosis of syphilis is certain. Meanwhile the local condition should be treated by frequent irrigation with biniodide of mercury solution (1 : 1,000), and by the application of boric ointment on a piece of lint inserted between the labia. After the lymphangitis has subsided the ulcers are best treated with a dusting powder such as aristol. If the inguinal glands suppurate they must be opened.

Secondary lesions may be similarly treated, the patient having been put on a mercurial course or treated by salvarsan. Tertiary lesions require iodide of potassium internally, combined with mercury. Reference has already been made to the local treatment of phagedæna.

Venereal warts should be snipped away with scissors. Oozing may be considerable, but can be checked by sutures or by the light application of a dull-red cautery. Elephantoid hypertrophy of the labia minora is treated by excision.

TUBERCULOUS VULVITIS

This is very rare, and is almost invariably associated with tuberculosis elsewhere. The ulcers are very painful, often foul, and may even be mistaken for malignant disease on account of the granulomatous thickening of the tissues. The diagnosis can only be made by examination of an excised portion of the tissue. The ulcers should be scraped with a sharp spoon until healthy tissue is reached, and carbolic acid then applied. In some cases excision of the diseased area is feasible. Vaccine treatment is of value.

HERPES OF THE VULVA (APHTHOUS VULVITIS)

Occasionally shallow, whitish excoriations are found on the vulva, producing considerable irritation. They are distinguished from venereal disease by the absence of swelling, of labial lymphangitis, and of glandular enlargement. Their cause is unknown: clinically they

resemble aphthous ulcers of the mouth. Bathing with a simple antiseptic lotion suffices.

LEUCOPLAKIC VULVITIS

This affection has only of comparatively recent years been distinguished from kraurosis of the vulva. Its cause is unknown. It begins as a diffuse redness with intense itching; later on the surface becomes white from epithelial hypertrophy, and the thickened tissues retract, so that the labia minora and hood of the clitoris almost disappear. The subepithelial changes consist of diffuse lymphocytosis, the appearance of plasma cells and complete disappearance of elastic fibres. (Fig. 582.) Painful fissures may develop, and in many cases squamous-celled carcinoma supervenes. In others, extensive subepithelial fibrosis results, and the parts present a white and "ironed-out" appearance. This is a quiescent stage, in which the characteristic intense pruritus disappears, while the liability to carcinoma diminishes.

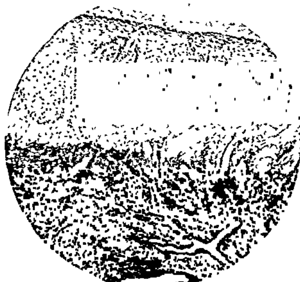


Fig. 582.—Leucoplakic vulvitis.
The epithelium is thickened and the tissue immediately underlying it is devoid of elastic fibres

The disease is most intractable, the pruritus often defying all treatment. Pathologically it is of great interest, as, next to X-ray burns, it affords the best example of a precarcinomatous state.

The parts affected are the labia minora, the hood of the clitoris, the inner surface of the labia majora, and sometimes the skin as far back as the anus. The vestibule and vaginal introit escape.

Treatment.—Of the many applications used for relief of the pruritus, those most likely to succeed are zymocide lotion and resinol ointment, but weak alkaline carbolic lotion (phenate of soda) is also useful. Iodide of mercury ointment may also be tried These failing, recourse may be had to the X-rays and to zinc-mercury ionization; but the effect of the former must be carefully watched, for it may hasten the appearance of carcinoma. In the last resort the affected parts must be excised.

KRAUROSIS VULVÆ

This condition was first described by Briesky. In the early stage multiple red patches are seen around the vaginal introit and on the vestibule. The urethra is usually carunculous. Microscopically, the red patches consist of massive aggregations of plasma cells with many dilated capillaries. The epithelium over them is thinned. Later, shrinkage occurs around the introit, while the whole vulva becomes atrophic and its inner surface smooth and shiny. Great soreness and dyspareunia are early symptoms; later the dyspareunia may also be experienced by the male. The disease is very intractable. In the earlier phases sedative ointments may be tried. Dyspareunia or other distress is best treated by dissecting out the diseased area and at the same time performing a plastic operation to enlarge the vaginal orifice (p. 10). Recurrence is common.

URETHRAL CARUNCLE

A urethral caruncle appears as a bright scarlet "cockscomb-like" protuberance from the posterior edge of the urethral orifice. Occasionally, however, the whole orifice may be carunculous without localized protrusion. The formation is entirely inflammatory, and microscopically presents the features of a massive plasma-cell aggregation (*plasmoma*) intermixed with lymphocytes. Its colour is due to numbers of dilated thin-walled capillaries. Embedded in its deeper parts may be found elements of the urethral glands. The condition usually occurs in elderly women, and frequently in association with kraurosis, to which disease it bears a definite histological relation; but it is occasionally seen in the young. The symptoms are those of great soreness, dysuria, dyspareunia, and occasional bleeding, but sometimes a caruncle may inexplicably cause no symptoms. The caruncle should be snipped off with scissors and its base well burned with the cautery. Recurrence is extremely likely; if this happens, the lower end of the urethra should be dissected free and removed, and the cut edge of the upper portion sutured to the vestibular mucosa.

ABSCESS OF THE VULVA

The labia majora are occasionally the seat of boils or carbuncles. Suppuration may also occur in one of the numerous glands of the lesser lips. The commonest form of vulval abscess is that of Bartholin's gland at the vaginal introit. Primary infection of this gland is common in gonorrhœa, but may also be due to non-venereal pyogenetic cocci Frequently a retention cyst of the gland has preceded the infection. Redness, swelling and pain appear in the neighbourhood of the gland, and pus eventually points on the inner surface of the swelling. Where the condition is complicated by previous cyst-formation, a persistent

sinus leading to the cyst-wall is commonly formed. In any case there is a great tendency to repeated recurrence. Boric-acid fomentations should be applied, and the abscess opened and drained. If a cyst is present an attempt should be made to remove the wall, otherwise a sinus will remain.

VULVAL CYSTS

BARTHOLINIAN CYST

A cyst is frequently formed in the duct of Bartholin's gland—always, probably, as the result of previous inflammation. It presents as an oval swelling bulging inwardly into the introit and outwardly under the lower end of the labia. *It is always unilocular, and contains a* clear mucus, unless inflamed, when the contents may be brownish and thick, or frank muco-pus. Complaint is made of discomfort and the presence of a swelling; if inflammation occurs, pain is severe. The cyst should be excised whole, through an incision over its inner surface. Where suppuration has occurred, this dissection may be impossible. *As much as possible of the cyst-wall should then be removed and the* cavity packed lightly with gauze and allowed to granulate.

LABIAL CYSTS

In the labia majora sebaceous cysts are not uncommon. A cyst of the vestigial "canal of Nuck" (*hydrocele of the canal of Nuck*) is sometimes seen as an elongated swelling extending downwards from the external inguinal ring, and may be mistaken for an inguinal hernia and especially for a hydrocele of a hernial sac. In the labia minora sebaceous cysts are also met with. Occasionally thin-walled pedunculated cysts occur containing a clear fluid. They probably represent distended odoriferous (Tyson's) glands. The cysts, of whatever nature, should be excised. A hydrocele of the canal of Nuck may communicate with the peritoneal cavity, and may be difficult to distinguish from a hernial sac; therefore its interior and contents should always be examined before excision.

URETHRAL CYSTS

Skene's tubules, or the numerous crypts opening through the posterior urethral wall, may occasionally be the origin of cysts. They present as a rounded fluctuating swelling that bulges into the vagina. They resemble a urethrocele, but a sound inserted into the urethra does not pass into the swelling. They may contain pus. If they give rise to trouble they should be dissected out.

OTHER INNOCENT GROWTHS

Venereal warts have already been considered (p. 5). Solitary non-venereal papillomas and soft fibromas, often pedunculated, are occasionally

seen. Lipomas may occur in the labia majora or mons Veneris. Very rarely solid adenomas springing from the sebaceous or odoriferous glands have been recorded. The treatment in all conditions consists in excision.

VULVAL NEW GROWTHS

MALIGNANT GROWTHS

Squamous-celled *carcinoma* of the vulva is not uncommon, and its almost constant association with a pre-existing leucoplakic vulvitis (p. 6) has been noted

There are three common clinical forms—(1) the warty, (2) the ulcerative, and (3) a superficial erosive, which at first sight does not perhaps suggest malignancy.

The disease occurs in older women, and may at first run a slow course. Eventually the inguinal glands become affected, rapidly enlarge, and soften and break down.

There is a fourth, and rarer, type, viz. that analogous to "sweep's cancer" of the scrotum, which usually begins on the labia majora. Lastly, examples of adeno-carcinoma originating either in Bartholin's gland, or in some other of the glandular structures scattered about the vulval surface, are on record.

Sarcoma of the vulva is known, and is sometimes of the melanotic variety.

Treatment.—The whole vulva should be excised, together with the inguinal glands on both sides.

In excising the vulva, two incisions are required, an outer, which comprises the whole area, and an inner, to exclude the orifices of the vagina and urethra. At the conclusion of the operation these latter are stitched to the skin edges of the wound.

THE VAGINA

DEFORMITIES

In early fœtal life the Mullerian ducts end blindly in the Mullerian tubercle, an eminence lying in relation with the bladder and Wolffian ducts in front, the lower bowel behind, and the urogenital sinus below.

The Mullerian ducts fuse below to form the uterus and vagina, and the tissue between the Müllerian tubercle and the wall of the urogenital sinus is gradually hollowed out until the vagina opens on the surface.

IMPERFORATE VAGINA ("IMPERFORATE HYMEN")

[illegible] Mullerian tube [illegible] presents part [illegible] imperforate, and in these cases it may be seen stretched out on the septum but not forming part of it.

Clinical features.—*The girl does not menstruate, and after a time* complains of periodic attacks of pain lasting for some days. These increase in severity and duration, until in advanced cases the patient is never free from pain. The abdomen becomes swollen and tender, and micturition is difficult.

These symptoms are due to the progressive distension with retained blood, first of the vagina (*hæmatocolpos*), and later of the cervix (*hæmatotrachelos*) and Fallopian tubes (*hæmatosalpinx*). The uterus itself is very rarely distended.

The distension of the tubes is soon followed by more or less pelvic peritonitis, attributable to the escape of the blood through the abdominal ostia (*hæmatocele*).

On abdominal examination a definite swelling is felt. If there is much tenderness, distension of the tubes may be inferred. Vaginal examination reveals the stretched septum, bulging, very tender, and of bluish colour owing to the blood behind it.

Treatment.—*The retained inspissated blood must be evacuated by* free crucial incision of the septum with most rigid aseptic precautions; if the cervix and tubes are distended there is a peculiar liability to ascending infection, which, leading to acute salpingitis, may cause death from general peritonitis.

Where hæmatocolpos alone exists, i.e. where the enlarged uterus can be felt on the top of the distended vagina, evacuation may be accelerated by flushing out the collapsed vaginal cavity with hot sterile water. If, however, there is any suspicion that the uterus itself is distended, it is better not to douche, lest the fluid be driven up the distended tubes. In these cases the vagina should be simply allowed to drain, the patient being kept in the *sitting posture.*

ABSENCE OF THE VAGINA, COMPLETE OR PARTIAL

The whole vagina, or its upper, middle, or lower third, may be absent. The defect arises from failure in the complete formation of the Müllerian ducts.

Clinical features.—Patients suffering from this deformity seek advice on one of three grounds—(1) amenorrhœa, (2) symptoms of retained menstrual blood, or (3) marital difficulty.

Treatment.—Since these graver vaginal defects are commonly associated with uterine maldevelopment, or absence of the uterus altogether, [illegible] however, [illegible] and re- [illegible] worth *attempting*, if the [illegible] section between the bladder and the rectum the distended cervix or upper part of the vagina, as the case may be, is reached. The retained blood having been evacuated, the wall of the cavity is freed, pulled down, and sutured to the lower part of the canal or to the surface skin. Systematic dilatation must be employed for many months afterwards. When the vagina is entirely absent the uterus is practically always absent as well, though the ovaries are usually well formed and the sex sense normally developed.

In such cases it is possible to make an artificial vagina by transplanting a loop of ileum. About 6 in. of the bowel is isolated with the corresponding

be made into a single ... serves its intended purpose well.

The operation should only be performed on women either married or hoping to marry. Two cases thus operated on by the author were very successful.

DOUBLE VAGINA

of the vagina joined by sutures.

VAGINAL SEPTA

Occasionally an annular septum occurs in the vagina, giving rise to dyspareunia. It must be cut away if causing inconvenience; otherwise it should be let alone.

VAGINAL FISTULÆ

Vesico-vaginal fistulæ occur as a result of prolonged labour or of operative procedures. Uretero-vaginal fistulæ are occasionally met with after total hysterectomy and the radical operation for cancer of the cervix. Recto-vaginal fistulæ result either from laceration during childbirth or from an abscess in the recto-vaginal septum.

Treatment.—A vesico-vaginal fistula may be dealt with either by simply paring the edges and drawing them together by suture, or, when large or intractable, by separating the bladder and vaginal walls and suturing the aperture in each separately. In some cases it may be necessary to deflect a flap from the adjacent part of the vaginal wall to cover the deficiency, or the upper part of the vagina can be detached from the lower portion, closed, and left as an annexe of the bladder (*colpocleisis*) If these methods fail, the abdomen should be opened, the bladder separated from the vagina, and the apertures in each closed. It is absolutely necessary to cure cystitis, if it exists, before performing any operation.

A ureteric fistula, if the communication of the ureter with the bladder is still maintained, may be treated by paring and suturing, but otherwise must be dealt with by implantation of the injured duct into the bladder. It is undesirable to remove the kidney unless it is certain that the other one is enterely healthy. Recto-vaginal fistulæ should be sutured.

INFLAMMATION OF THE VAGINA

VAGINITIS

Inflammation of the vagina is best classified according to its cause, as follows :—

STREPTOCOCCAL AND STAPHYLOCOCCAL VAGINITIS

Both these varieties are common. The former may be very severe, the surface being erysipelatous, diphtheroid, or even gangrenous; such grave infections are most often the result of puerperal sepsis.

Streptococcal vaginitis of less intensity than this is, however, often seen both in married women and in virgins, and, whilst sometimes, no doubt, conveyed by intercourse, is by no means always so. It is often associated with streptococci in the urine.

It is a peculiarly intractable form of vaginitis, much more difficult to deal with than that due to the gonococcus.

Staphylococcal vaginitis is milder, as a rule, but only a bacteriological examination can distinguish it from that due to the streptococcus.

Vaginitis may result from injuries, operations, excessive chemical applications, the prolonged wearing of pessaries, or the presence of other foreign bodies.

The surface is red, smarting and painful, and a purulent discharge flows from the vagina. The cervical canal is often infected as well, and is apt to remain inflamed long after the vagina has recovered; by persistent re-infection it may render treatment directed to the vagina alone of no avail, particularly in the vulvo-vaginitis of children.

Diagnosis.—This is made absolute by bacteriological examination of the pus. The possibility of gonorrhœal origin must never be mentioned until bacteriological proof has been obtained. The vulvo-vaginitis of children, while sometimes gonococcal, is often staphylococcal or streptococcal, but parents are almost uniformly apt to assume the graver infection.

Treatment.—Antiseptic douching is necessary. In virgins, and particularly in children, the hymen may hinder douching and, by obstructing drainage, maintain the inflammation. Where an ordinary douche tube cannot be inserted a glass catheter may be used. The most efficacious douches are the chlorine preparations, like Dakin's solution, eusol, and Milton's solution. Flavine, 1 : 1,000, is also excellent. In intractable cases, applications of nitrate of silver, protargol, or one of the colloidal forms of silver are indicated.

Patients should be warned of the intractable character of the inflammation when it is streptococcal. Vaccines are of great use in these cases and should always be employed.

GONOCOCCAL VAGINITIS

The clinical features and treatment of this condition are discussed in Vol. I., pp. 866–69. The disease runs a more severe course when the hymen is practically intact, because drainage and medication are alike interfered with. The hymen becomes swollen, scarlet, and so sensitive that any attempt to pass a douche nozzle causes severe pain.

Complications.—Bartholin's gland often suppurates. Extension of the infection to the body of the uterus and to the Fallopian tubes is common, but does not usually occur for several weeks after the initiation of the attack. Gonorrhœal cystitis is also frequently met with.

After the disease has existed for some time the gonococci may apparently disappear from the discharge, their place being taken by diphtheroid organisms or streptococci, although the gonococci probably remain latent in the cervical and Bartholin's glands, and capable of infection. The secondary organisms may be passed from one individual to another, and vaginitis primarily due to diphtheroid organisms is well known.

Diagnosis.—No definite statement should be made unless supported by bacteriological proof; even then caution is to be observed.

The treatment of the complications of gonorrhœa generally has already been considered (Vol. I., p. 871 *et seq.*). During the acute stage, urinary antiseptics should be given to prevent cystitis.

NEW GROWTHS OF THE VAGINA

CYSTS

Although the vaginal wall normally contains no glands, small aberrant glandular retention-cysts are occasionally found there. They rarely exceed the size of a pea. A rare condition, *adenomatosis vaginæ,* in which the whole vaginal wall is beset with glands, was first described by the author and Glendinning.[1]

Thin-walled cysts sometimes occur on the lateral or lower part of the anterior vaginal wall. These are Wolffian in origin, and have been found extending up into the broad ligament in the course of Gartner's duct. They should be excised if they are causing trouble.

SOLID TUMOURS, INNOCENT AND MALIGNANT

Solid tumours of the vagina are very rare. *Myomas* are most often encountered. They appear as rounded hard tumours bulging into the lumen of the canal, and covered by the mucous membrane lining it. *Papillomas* and soft *fibromas* occur occasionally.

Malignant disease is most commonly secondary. Squamous-celled

[1] *Proc. Roy. Soc. Med.*, vol. iv.

carcinoma may be primary there, or secondary to a growth in the cervix. It assumes the form of a nodular ulceration. Adeno-carcinoma *secondary to carcinoma of the corpus is sometimes seen. Metastatic* nodules of chorion-epithelioma are relatively common in the course of this interesting disease, and in addition a good number of cases are recorded in which this variety of malignant disease has appeared there primarily.

Sarcoma of the vagina occurs both in children and in adults. In the former it assumes the same "grape-like" appearance that characterizes infantile sarcoma of the cervix. In adults it presents as a soft, red, "velvety"-surfaced mass. Both types are exceedingly rare.

Symptoms.—The innocent growths may give rise to no symptoms, or, by their size, may cause marital difficulty or pain. The malignant tumours present the clinical features common to them elsewhere.

Treatment. — The innocent tumours should be removed. Vaginal myomas are well encapsulated, and shell out easily.

Malignant disease of the vagina is a very serious matter, owing to the readiness with which it spreads to the rectum or bladder, and the frequency with which it is already inoperable when the patient presents herself. When limited to the vagina, the growth demands total removal of this canal together with the uterus—*total hystero-vaginectomy* (*see* under Carcinoma of the Cervix, p. 43). Where a small primary growth exists close to the outlet, the lower part of the vagina alone may be excised, and the upper portion pulled down and united to the skin.

THE UTERUS

DEFORMITIES

ABSENCE OF THE UTERUS

The uterus may be absent altogether. The deformity is, as a rule, associated either with deficiency of the vagina or with maldevelopment of the ovaries. The former are the cases in which the propriety of performing Baldwin's operation may be considered.

ATRESIA *OF* THE CERVIX

The cervix may become imperforate as a result of the application of strong caustics. Rarely, it is congenitally so. In either case, if the uterus be functional, retention of menstrual blood occurs. The site of retention varies: *if the obstruction be limited to the external os,* the cervix is distended first (*hæmatotrachelos*), and later the tubes; if the obstruction be at the internal os, hæmatosalpinx is usually the first event, the uterus distending subsequently. The clinical features are *those of retained menses with symptoms of hæmatosalpinx* and salpingitis. Communication with the vagina should be established if

possible. If, however, this cannot be done, or if the tubes are already disorganized, removal of the uterus and tubes is indicated.

DOUBLE UTERUS (Fig. 583)

The following degrees of double uterus depend on the extent to which the Mullerian ducts have failed to fuse:—

1. *Uterus duplex.*—Two distinct organs. A peritoneal fold from rectum to bladder passes between them.

2. *Uterus bicornis unicollis*—Two bodies joined to a single neck.

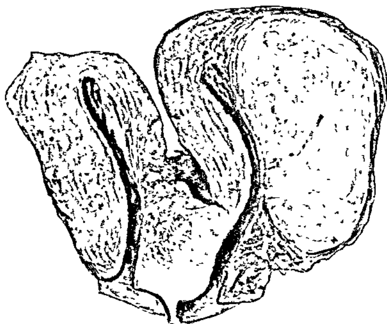


Fig. 583.—Double uterus.
The left horn contains a myoma. The septum dividing the vagina into two halves is shown

3. *Uterus unicornis.*—A bicornuate uterus in which only one body has developed, the other remaining as a narrow tube.

4. *Uterus septus.*—The uterus is outwardly single and of normal shape, but a longitudinal septum divides its cavity down to the external os.

5. *Uterus subseptus.*—A similar condition to No. 4, but the septum only reaches the internal os.

Clinical features.—The deformity usually causes no symptoms, and is only accidentally discovered. Though any uterine deformity militates against conception, repeated pregnancy has occurred in one half of a double uterus; a decidua is formed in the unimpregnated half, and is expelled after the labour.

Pregnancy sometimes occurs in the undeveloped horn of a unicorn uterus and runs the same course as pregnancy in the Fallopian tube, except that rupture is less common and a greater proportion of the cases go on to term.

Hæmatometra in one half of a double uterus is occasionally met with, the symptoms being those of recurring monthly pain and a cystic tumour to one side of the apparently unenlarged uterus. There is, of course, no amenorrhœa. Septate uteri have been discovered during mechanical dilatation of the organ, the edge of the partition obstructing the passage of the dilator. The half of a bicornuate uterus has been found in the sac of an inguinal hernia, in the male as well as the female (internal pseudo-hermaphroditism).

Diagnosis.—Where two cervices exist, the diagnosis is obvious. With a single cervix, double bodies may be detected by bimanual examination. They sweep outwards in a characteristic manner parallel with Poupart's ligament. The passage of the sound will render the condition clear.

A uterus unicornis may be suspected from the presence of the peculiar outward sweep already mentioned, and only one uterus can be felt.

Pregnancy in an undeveloped horn can only be distinguished from a tubal pregnancy by noting the relation borne by the tumour to the round ligament, i.e. the ligament terminates in its outer side.

Hæmatometra of an undeveloped horn may be suspected from a consideration of the history, the youth of the patient, and the extreme lateroversion of the recognizable body of the uterus.

Treatment.—If symptoms are absent, nothing need be done; otherwise the uterus or the cornu at fault should be removed. The septum of a septate uterus can be removed and the two cavities thrown into one.

ELONGATION OF THE VAGINAL CERVIX

There are two main types of elongation of the vaginal cervix: (1) a so-called "congenital" elongation, occasionally seen in young women, in which the vaginal cervix, though so elongated as to protrude perhaps from the vulva like a polyp, is extremely thin; and (2) the acquired elongations most commonly due to chronic hyperplastic cervicitis, but more rarely to the development of a myoma, a carcinoma or sarcoma, or a large cyst in the cervical wall. In these cases the vaginal cervix is enlarged in every dimension.

Clinical features.—The congenital form may produce no symptoms and may be discovered accidentally. In the acquired variety the patient becomes aware of an abnormal mass filling the vagina or protruding from the orifice, and complains of a sense of

dragging or bearing down. If cervicitis be present, there will be leucorrhœa, pain in coitus, and occasional slight blood-stained discharges.

Diagnosis.—The congenital form may be mistaken for a polyp, but inspection of the most dependent part of the protrusion will show the external os, and careful vaginal examination will clinch the diagnosis.

General hypertrophy due to inflammation or new growth could only be mistaken for a tumour extruding through the external os, or for the body of a totally inverted uterus; careful examination will not fail to distinguish it from these conditions.

Treatment.—The congenital elongation should not be interfered with unless it causes annoyance or produces sterility; in such case it may be amputated circularly just below the vaginal vault. An acquired hypertrophy must be treated according to its cause. When it is due to cervicitis, circular amputation or tracheloplasty (p. 31) may be performed; when it is the result of new growth, the appropriate treatment must be carried out.

DISPLACEMENTS OF THE GENITAL CANAL

In the past the displacements of the genital canal have always been described as though each were an independent entity, with the result that the teaching was chaotic. I shall consider the subject from a wider viewpoint which recognizes that the various forms of displacement are intimately linked together, though the mechanism of each is peculiar to itself.

Supporting mechanism of the genital canal (Fig. 581).—To explain displacements it is essential to understand the means by which the genital canal is held in its normal position. The supporting structures are most usefully divided into three segments.

1. **Upper segment.**—This comprises all the structures attached to the uterus above the level of the cardinal ligaments of the vagina (lateral cervico-pelvic ligaments, Mackenrodt's ligaments). It comprises the peritoneal layers of the broad ligaments, the ovario-uterine and ovario-pelvic ligaments, the round ligaments, the perivascular sheaths of the ovarian and uterine arteries, and the adjacent cellular tissue. All these structures, being attached to the uterus, assist in keeping it in position, for though none of them is individually of much strength, yet collectively they have a definite value, a fact that is exemplified by observing the mobilization of the uterus that follows their division in the course of abdominal hysterectomy.

2. **Middle segment.**—The middle segment consists of the cardinal ligaments of the vagina, structures of great strength and

importance—a fact which had been insufficiently realized before the initiation of the radical abdominal operation for cancer of the cervix. They consist of a series of fibres which radiate strut-like from the sides of the cervix and vagina to the lateral pelvic wall and the fascia covering the upper surface of the levator ani muscles. The most posterior fibres run backwards and outwards, forming ridges which, covered by

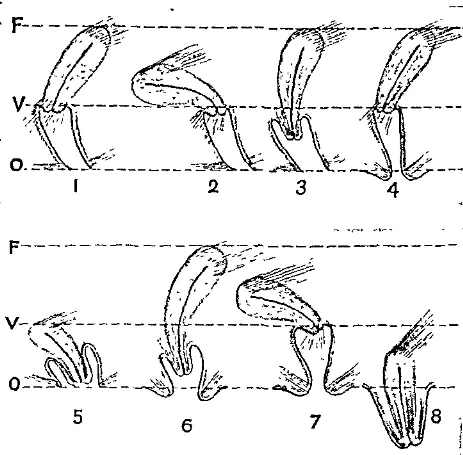


Fig. 584.—Diagram to illustrate displacements of the genital canal. F, Normal level of the uterine fundus. V, Normal level of the vaginal vault. O, Normal level of the vaginal outlet. The three segments of the suspensory apparatus are indicated by fine lines.

1, Norr

(complete prolapse).

peritoneum, are known as the utero-sacral ligaments. The middle fibres come off from the lateral wall of the vagina and the cervix at

different levels, like a series of flying buttresses one above the other, the upper ones passing to the bony wall of the pelvis, and those beneath them to the fascia covering the levator ani—an arrangement that may be likened to that employed by house-builders when temporarily shoring up an unstable wall. The anterior fibres run forwards and outwards under the bladder base and the uretero-vesical junction on each side, but a few of the more superficial ones pass over the ureter to blend with the lateral ligaments of the bladder and form the roof of the ureteric canal.

The inner edges of the anterior portions of the cardinal liga-

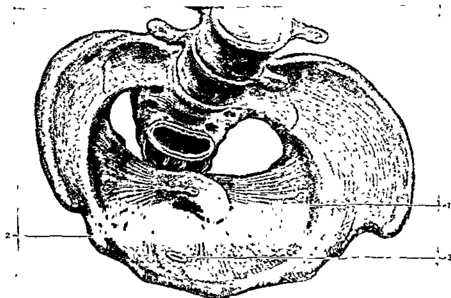


Fig. 585.—Diagrammatic illustration of the cardinal ligaments of the vagina ([illegible] fibres: [illegible] at about [illegible]

1, Cardinal ligaments. 2, Pubo-cervical fascia; the bladder rests on its upper surface, and the anterior vaginal wall lies immediately below it. 3, The urethra perforating the fascia.

ments are not contiguous, but are separated by a space filled up by a fascial plane attached laterally to the inner edges above mentioned, anteriorly to the back of the pubic symphysis, and posteriorly to the anterior face of the cervix at the junction of its supravaginal and intravaginal portions. The base of the bladder rests on this pubo-cervical fascia, which separates it from the anterior vaginal wall lying immediately underneath it.

The strong upper fibres of the two cardinal ligaments maintain

the vaginal vault and the cervix in position, while those lower down keep the lateral vaginal walls rigidly supported. The anterior and posterior vaginal walls are not directly supported by them, and consequently are much more mobile than the lateral walls. (Fig. 585.)

3. The **lower segment** consists of the pelvic floor proper—that is, the levatores ani muscles and the fasciæ covering them above and below, the triangular ligaments, Colles's fascia, and the superficial perineal muscles, together with the wedge-shaped perineal mass which, by maintaining the sharp forward curve of the lower end of the vagina, gives support to the lower part of its anterior wall. The lower segment directly supports the lower end of the vagina, which obtains firm attachment to various structures comprising it and indirectly supports the lateral vaginal walls above the pelvic diaphragm in virtue of the fibres, previously described, that pass between the lateral walls and the fascia covering the upper surface of the levatores ani muscles.

Mechanism of displacement (Fig. 584).—All forms of displacement are due to weakness either of part or the whole of the supporting apparatus. Such weakness is most commonly the result of childbearing, the tissues being stretched beyond their power of return. Stretching is a far greater factor than tearing, which indeed is sometimes actually conservative in that the rupture saves the stretching This accounts for the well-known fact that prolapse is rare with complete rupture of the perineum. Violent strain apart from childbearing is capable of causing overstretching of the supporting mechanism, especially of the relatively weak upper segment, and cases of retroversion are often met with due to this cause. Finally, the supporting apparatus may be naturally deficient in strength; extreme examples of this are occasionally met with, in which prolapse has been present even at birth, though as a rule the results of the tissue weakness are not apparent until after puberty. Many cases of retroversion in young unmarried girls, and sometimes of prolapse in young nulliparous women, are no doubt to be thus explained.

Varieties of displacement.—*It follows that there are* seven clinical varieties of displacement, according to whether one segment singly, two segments in combination, or the whole three segments have yielded.

1. **Yielding of the upper segment (retroversion).**—This results in retroversion of the uterus. For the full degree of the displacement certain of the upper fibres of the middle segment must yield also, to allow the cervix to tilt forwards, but, in the main, retroversion may be considered as an upper-segment deficiency. On the degree to which the fibres steadying the cervix resist the stretching process, and on the consistence of the uterus, depends the extent to

which the uterus bends backwards as well, but retroflexion practically never occurs without retroversion.

2 **Yielding of the middle segment (vaginal inversion).**—This mobilizes the vaginal vault and allows the intra-abdominal pressure to invert it, accompanied by the cervix, into the vagina. This descent being resisted by the upper supporting segment, if that segment is normal, the uterus becomes stretched, especially in the supravaginal cervix, which becomes considerably elongated.

3. **Yielding of the lower segment (vaginal eversion).**—Of the many components of the lower segment the levatores ani muscles are the most important. Labour often leaves these muscles permanently relaxed, so that the horseshoe-shaped gap between their anterior edges, through which the vagina and urethra pass, is much enlarged and the whole muscle plane drops like an ill-slung hammock. In addition, deficiency of the perineum, due to ununited laceration, and permanent laxity of the vaginal walls are usually present. The anterior and posterior vaginal walls are thus unsupported, and the vagina tends to become everted.

The eversion may affect anterior or posterior wall alone, or both together. The lateral walls practically never descend, on account of the strut-like fibres of the cardinal ligaments previously described. To the protrusion of the anterior and posterior vaginal walls the terms "cystocele" and "rectocele" are applied, but it does not follow that the bladder and rectum descend also; indeed, in many cases these organs remain practically in their normal position.

The base of the bladder is supported by the sheet of fascia already described as filling the gap between the anterior edges of the cardinal ligaments. Laxity of this sheet, however, at once allows the intra-abdominal pressure to push the bladder down between the anterior edges of the cardinal ligaments, and the vaginal protrusion is then accompanied by a true cystocele. Such laxity very commonly accompanies lower-segment deficiency, and may on rare occasions exist without it, so that cystocele may occur with a perfectly normal vaginal outlet.

The rectum is held up by the lateral ligaments of the rectum and the peritoneal folds and mesentery higher up, and the posterior vaginal wall may slip away from its loose attachment to the anterior rectal wall and protrude through the vaginal orifice unaccompanied by any pouch from the rectum so long as the supports of the rectum continue to function, but if they too are relaxed the rectum pouches forwards and a true rectocele is formed.

4. ***Yielding of the upper and middle segments.***—*This results* in the uterus retroverting and the vaginal vault inverting simultaneously. The inverting vault is accompanied by the whole uterus,

there being no resisting upper segment to balk the inverting movement.

5. **Yielding of the upper and lower segments.**—The vagina makes a "turning-inside-out" movement both from above downwards (inversion) and from below upwards (eversion). The everting movement tends to mask the inverting movement, but the latter can be disclosed by holding up the cystocele and rectocele with the fingers while the patient coughs or bears down; the excessive descent of the vaginal vault then becomes apparent. A great strain is thrown on the upper segment, which sooner or later gives way under it.

6. **Yielding of the upper and lower segments.**—This results in retroversion combined with rectocele and cystocele, a very common combination.

7. **Yielding of all three segments.**—Inversion and eversion of the vagina go on together unresisted, for the upper segment also is worthless. The uterus is dragged down by the inverting vaginal vault, and the vagina ends in being turned completely inside out (extroversion). It is noticeable that the smaller the uterus the easier is it for the vagina to turn inside out, and most of all when there is no uterus. This is why complete prolapse is usually seen in old women in whom the uterus has atrophied, and why removal of the uterus for the cure of prolapse not only fails in its intent but makes matters worse.

Symptoms.—A very constant symptom of genital displacement is pain or discomfort. As in other deformities, the pain bears no constant relation to the degree of the deformity; in fact it is often most pronounced when the displacement is slight and in its initial stage.

The character of the pain varies. In retroversion it is chiefly felt in the back, and on one or both sides of the abdomen above and parallel to the groin, whilst in vaginal inversion and eversion it is of a bearing-down character and is referred to the passage itself; but since the various displacements are often combined, pain may be complained of in all these sites.

An even more constant symptom than pain is a sense of discomfort or weakness ("as if my inside is falling out"). Patients often state that this sense of weakness dates from the birth of a child, and that walking, even for half a mile, now causes exhaustion. At the menstrual periods the pain becomes accentuated, or mere discomfort passes into pain (congestive dysmenorrhœa), while retroversion, especially when the ovaries are prolapsed under the uterus, is productive of dyspareunia.

The effect of genital displacement on childbearing depends on the displacement. A retroverted uterus is unlikely to conceive, and, if conception does occur, early miscarriage is likely. If the embryo survives, the displacement will gradually be rectified as the uterus

enlarges, but until the uterus has risen out of the pelvis there is always the risk of its becoming incarcerated.

As regards menstruation, the loss is frequently excessive or repeated too often, not merely on account of the deformity but because the same want of involution which left the sustentacular apparatus lax has caused the uterus to remain permanently enlarged and hypervascular. There is no doubt, however, that marked retroversion does in itself produce a swollen, congested state of the organ, and as many of these patients have coexistent cervicitis and erosion a tiresome discharge goes on between the excessive and painful periods.

In vaginal prolapse the patient is from the first conscious of a descending mass within the vaginal orifice. When actual protrusion occurs the exposed vaginal wall or cervix gets rubbed and, in long-standing cases, actually ulcerated. These ulcers are callous in appearance and may be mistaken for carcinoma, though they rarely become cancerous. A large cystocele causes difficulty in micturition, which perhaps cannot be satisfactorily accomplished until the protrusion has been pressed up by the fingers.

Rectocele accompanied by pouching of the bowel occasions that form of constipation in which, though fæces have reached the rectum, they cannot be extruded through the anus. This is accentuated by the lax state of the levators, which are unable to pull the last inch of the anus over the extruding scybalæ. With retroflexion and a degree of descent of the vaginal vault the action of the bowel is obstructed by the retroflexed uterus being forced into Douglas's pouch like a ball-valve every time the patient strains at stool. Rectocele with pouching often coexists with this condition, and a state of intestinal stasis is induced which entirely disappears on operative rectification of the deformities, as McCrea has pointed out.

Diagnosis.—Retroversion, and particularly retroflexion, have to be diagnosed from tumours lying behind the uterus in Douglas's pouch. The direction of the cervix indicates the axis in which the body of the uterus is lying, whilst in backward displacement the uterus is absent from its normal position on bimanual examination. The most difficult cases are those in which a tumour lies behind a retroverted uterus; examination under an anæsthetic and the passage of a sound may then be required before a diagnosis can be made.

Prolapse of the vagina is in general easily recognized, but an elongated cervix, or a fibroid extending through the cervix, may be mistaken for an inverted vaginal vault, and a tumour of the vaginal wall for a rectocele or a cystocele.

Recognition of the exact variety of prolapse has an important bearing on the treatment. Thus, pure inversion of the vaginal vault is entirely restrained by holding up the cervix in its normal position

either by the finger or a volsella, whilst in those cases in which eversion and inversion *coexist the inversion can be disclosed by holding up* the lower halves of the anterior and posterior walls and noticing that in spite of this the cervix and vaginal vault descend abnormally.

In pronounced inversion the anterior vaginal wall may bulge at the vaginal orifice and simulate a true cystocele; but if the vault be prevented from descending, by holding up the cervix, it will be found that the vaginal descent is entirely restrained, whereas a true cystocele is not influenced by holding up the vault.

Treatment. Pessaries.—The operative treatment of genital displacement has been so improved of modern years that pessaries have fallen into desuetude. Their scope should be restricted to cases in which the wearing of a mechanical support for a few months is reasonably likely to effect a permanent cure, and to those in which, owing to age or other disability, an operation is not indicated.

Into the first class fall cases of retroversion or vaginal inversion occurring directly after labour. In such, if the uterus or vaginal vault can be held in position for some months, the natural involution of the parts may make the rectification permanent. The particular shape of pessary employed does not matter if the parts are kept in *proper position. On the whole, the rubber ring pessary is the most* efficient. If after the lapse of six months the malposition returns on removal of the pessary, an operation is indicated.

To the second class belong cases of prolapse in aged women, especially of the hospital class, whose health makes an operation undesirable or whose occupation does not admit of the necessary expenditure of time Age in itself is not a contra-indication if the patient be hale and hearty, with a life expectation of some years, and I have on many occasions operated on women over 70 in whom pessaries had failed to restrain the prolapses. The best sort of pessary for this type of patient is the rubber stem, which can be taken out and washed at night and replaced in the morning. The rubber ring which can only be changed every two or three months is a filthy contrivance for the poorer and more neglectful class of patient, and speedily becomes soaked in foul-smelling pus; but where the woman can afford to have it seen to frequently, and uses douches regularly, it is less objectionable. Some patients learn to take the ring out and wash it themselves, and all should be told to endeavour to do so.

Operations.—The operative treatment depends upon the variety of the displacement.

For retroversion many operations have been devised, but the best two are intraperitoneal shortening of the round ligaments and ventro-fixation.

Shortening the round ligaments.—The original operation devised by

Alexander was extraperitoneal, the ligaments being exposed at the external abdominal ring. Since only cases of movable retroversion could be so treated, the operation has been largely given up in favour of *intraperitoneal ligamentopexy*. There are many ways of performing this operation. The most ingenious and best is as follows: The abdomen having been opened, and the uterus anteverted, a ligature is passed under each round ligament about ¾ in. from its uterine attachment, and tied, the ends being left long. A special curved forceps is then inserted through a little slit in the aponeurosis ½ in. outside the edge of the wound, and is pushed outwards, first between the rectus muscle and aponeurosis, and subsequently between the aponeurosis and peritoneum, till the internal abdominal ring is reached. The point of the forceps (still extraperitoneal) is now made to return towards the middle line under the peritoneum of the broad ligament and parallel to and just in front of the round ligament. When it has reached the position of the previously applied ligature it is thrust through the peritoneum and the ligature ends are grasped and withdrawn along the track taken by the instrument.

The forceps being removed, traction is made upon the ligature ends until a knuckle of round ligament appears at the aponeurotic slit. A similar proceeding having been carried out in the opposite side, each *knuckle is fixed by the suture closing the little slit in the aponeurosis* on its own side, and the abdominal wound is then sutured.

This proceeding shortens the whole of the front part of the broad ligament on either side and leaves the uterus in a truly normal position. It is, therefore, a better operation than ventro-fixation for retroversion, but is inadvisable where prolapse also exists, as it does not effect a sufficiently direct upward pull on the uterus.

Ventro-fixation consists in fastening the upper part of the anterior uterine wall to the anterior abdominal wall by three or four silk sutures that, picking up the superficial muscular layers of the former, pass through the peritoneum and aponeurosis on either side of the wound. A strong peritoneal adhesion is thus formed, which gradually stretches into a short artificial ligament about ½ in. long.

Ventro-fixation thus performed is a very satisfactory operation and does not interfere with subsequent pregnancy. Where, however, the fundus or posterior wall or one of the cornua has been attached instead of the anterior wall, great difficulties both in pregnancy and in labour have been experienced. Cases are on record of intestinal obstruction by the artificial ligament, but this sequel is very rare.

The operation to be selected in a case of **prolapse** depends upon the exact variety of the displacement, no one operation being applicable to all.

Thus, in a case of pure inversion of the vagina (a rare form, chiefly

seen in congenital prolapse), in which the middle segment of the supporting apparatus alone is lax, the surgeon has the choice between repairing the faulty segment and constructing a new support to take its place. In the first alternative he will perform a wide colporrhaphy of the vault, laying bare the fibres of the cardinal ligaments, which can be tautened by suturing them together in front of the cervix. In the second alternative he will suture the front of the uterus to the anterior abdominal wall (ventro-fixation) and so make the uterus into a direct ligament holding up the vaginal vault. In either case it will be necessary to amputate part of the cervix, which is always much elongated in these cases (p. 23). In an extreme case he can combine these operations.

Where the prolapse takes the form of an eversion of the vagina, anterior colporrhaphy and perineoplasty are indicated, the most important thing about the latter operation being the suture of the levatores ani muscles.

Where the prolapse is due both to inversion of the vault and eversion of the lower end of the vagina, the operations mentioned for inversion and eversion separately will have to be combined. Thus, anterior colporrhaphy can be combined with amputation of the cervix, wide excision of the lateral fornices, and suture of the cardinal ligaments, whilst colpo-perineoplasty can be extended upwards until the area of excision of the vaginal wall includes the posterior vault.

In complete prolapse, where the uterus as a whole, and not merely the cervix, comes down with the inverting vault, ventro-fixation should be combined with the vaginal operations mentioned.

The particular set of operations to be done in any given case should depend on the nature of the deformity and the class of the patient. It is possible to cure complete procidentia by vaginal operation only, but this in some cases will necessitate considerable narrowing of the canal, which is undesirable in many women. Where it is thus *undesirable, ventro-fixation offers a means of holding up the vault* without excessively narrowing it, but the vaginal walls lower down will require reconstituting as before.

For old women with complete vaginal prolapse, le Fort's operation, which consists in making a medial septum down the vagina, is successful.

For the detailed methods of performing the operations named, the reader must be referred to textbooks of gynæcological surgery.

INVERSION OF THE UTERUS

This rare displacement most often occurs immediately after childbirth. Occasionally, however, cases of chronic inversion are seen, with an obscure relation to parturition.

Three degrees of inversion are described—(1) where the inverted fundus is still within the uterine cavity; (2) where it is extruded from the external os; and (3) where the entire body and cervix is turned inside out.

Clinical features.—The accident, when occurring after labour, is marked by severe shock and hæmorrhage. In chronic cases there is bearing-down pain, with bloody discharge which may be offensive. The everted uterine mucosa becomes ulcerated or may superficially slough. (Fig. 586.)

Diagnosis.—The mass might be mistaken for a protruding myoma, but careful examination and the passage of a sound make the condition clear.

Treatment.—A puerperal inversion must be at once reduced by manipulation, but chronic cases can rarely be so treated. The recognized method for these is the use of the Aveling repositor, i.e. a boxwood cup on a rigid stem, which is kept pressed against the inverted fundus by indiarubber straps attached to a waistband. It is important to place tampons around the repositor to keep it from slipping off the mass to which it is applied. After twenty-four hours it will usually be found that the displacement has been corrected.

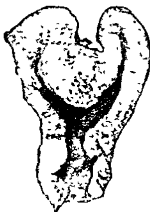


Fig. 586.—Partial inversion of the uterus.

If the repositor fail, the utero-vesical pouch may be opened from below, and the everted anterior wall of the uterus incised from the cervix downwards. The cupped interior of the inversion is thus laid open, the adherent appendages which prevent its reposition are freed, the inversion is reduced, and the wound in the anterior uterine wall and vaginal cervix subsequently closed by sutures. An alternative procedure is to open the abdomen and incise from above the posterior wall of the cup. Finally, the inverted uterus may be removed from below.

INFLAMMATION OF THE UTERUS

ENDOCERVICITIS AND CERVICAL "EROSION"

Cervicitis may be caused by direct extension upwards of a vaginitis, or may be part of a general uterine infection following labour or abortion. It may also follow obstetric lacerations or operative wounds.

The normal virgin cervical canal is probably bacteriologically sterile. The vagina, on the other hand, always contains organisms. The vaginal epithelium is remarkably thick and resistant, whilst that of the cervical

Clinical features.—The leading symptom of chronic cervicitis is leucorrhœa, popularly known as "the whites." The mucus escaping from the cervix is transparent, but after mixture with the creamy-coloured vaginal secretion it becomes whitish and streaked. It is most copious in the earlier stages of cervicitis, and gradually lessens as the glands become occluded. The cervix is often the seat of old ununited laceration. It is doubtful if chronic cervicitis *per se* can cause pain, but inasmuch as it is often associated with endometritis, retroversion or prolapse, or other abnormal conditions of the genital organs, it is often associated with pain. In some cases streptococci can be isolated, and in such the cervix is an area of possible toxic absorption leading to generalized ill-health.

Differential diagnosis.—Cervical "erosion" in its earlier phases is readily distinguishable from carcinoma of the cervix, but when severe and old-standing may simulate it so closely that diagnosis can only be made by microscopy. Nor is this surprising, since erosion is the constant precursor of carcinoma.

In general, though slight oozing may follow examination, an erosion never bleeds freely, and though its surface may be irregular and rough, the consistence of the tissues is firm. Carcinoma, on the other hand, always bleeds more or less readily, and its surface, in addition to being irregularly excrescent, is friable. In all cases of doubt a microscopical examination should be made.

Treatment. — Chronic cervicitis may be treated either by applications or by operation.

Applications.—Douches are customarily prescribed for leucorrhœa. Although vaginal irrigation applies chemicals but inefficiently to the cervical canal, it is of use, inasmuch as it washes away the discharge, benefits the surface of the erosion, and allays vaginitis. In the more acute stages antiseptic solutions should be used, such as Milton's solution (2 drachms to a pint of water), flavine (1:2,000), or lysol (1 drachm to the quart). Later, astringents are employed, such, for example, as tannic acid, alum, or sulphate of zinc (2 drachms to the quart)

Soluble vaginal pessaries containing ichthyol or other drugs in a glycerine basis are a more potent method of making applications to the cervical surface.

The direct application of antiseptics such as carbolic acid or "iodized phenol" (iodine 1, phenol 3) on a swab is the most efficient method of direct medication, and if persisted in cures a certain proportion of cases. It is, however, a lengthy, troublesome, and uncertain means of treatment.

Operations.—*Scraping* the diseased cervical mucosa with a sharp scoop may be tried. Not infrequently it is also necessary to curette

the corporeal endometrium, but, owing to the depth to which the cervical glands penetrate the tough cervical tissue, nothing short of the vigorous application of a strong, sharp scoop will suffice to eradicate them. The surface of the erosion is similarly treated. In bad cases the following operation should be performed.

Amputation of the vaginal cervix.—Two flaps of cervical mucous membrane, one anterior and one posterior, are made, the cervix amputated circularly, and the flaps sutured to the edge of the cervical canal. It is the best operation for persistent and severe chronic cervicitis, and is especially indicated where the vaginal cervix is much hypertrophied. As much or as little of the cervix can be removed as the operator pleases. In many cases excision of the eroded area alone is required.

Trachelorrhaphy used to be performed when, in addition to the cervicitis, the cervix was badly split. The lips of the laceration are denuded on their inner and opposed surfaces, except for a narrow strip in the centre of each, and they are then approximated by sutures, so that most of the eroded area is removed and the laceration repaired at the same time. The operation is faulty, in that a strip of the eroded area is utilized to form the lining of the restored part of the cervical canal.

TUBERCULOUS CERVICITIS

This very rare condition usually coexists with corporeal disease. It presents as an ulcerating surface, commonly mistaken for carcinoma, but distinguishable from it by microscopy. It requires hysterectomy.

ACUTE ENDOMETRITIS

Pathology.—Acute infection of the interior of the uterus is most typically seen after labour and abortion. The streptococcus is usually found in the more virulent puerperal infections, but the pneumococcus, staphylococcus, and B. coli also occur. In the absence of recent pregnancy, acute endometritis is most commonly caused by the gonococcus, but it may also arise after operations, in the course of the extrusion of a polypus, or as a consequence of a breaking-down carcinoma

In acute streptococcal endometritis the mucosa is necrotic, either diphtheroid or foully sloughing, and the whole uterine wall is œdematous and often presents multiple abscesses In the less virulent infections, such as the gonococcal, the endometrium is frankly suppurating, the interglandular stroma is packed with polynuclear leucocytes, and much of the epithelium has desquamated.

Clinical features.—The symptoms of puerperal endometritis are those collectively known as "puerperal fever," a full description of which will be found in obstetrical textbooks Gonorrhœal endo-

glands in the hypertrophic stage also occasion a watery discharge, especially marked just after the "period." The latter is accompanied by an aching, bearing-down pain, referred to the lower abdomen, sacral region, and vagina. Dyspareunia may be complained of when the uterus is tender, and conception is unlikely.

There is a variety of the disease known as *senile endometritis*. In old age the uterine mucosa atrophies, nearly all the glands disappear, and the epithelium becomes flattened and often practically squamous. Owing to the absence of glands, the discharge from such a uterus, if infected, is purulent or seropurulent instead of being mucous as usual, and is very apt to become foul. Eventually the endometrium is replaced by a thin layer of red granulation tissue from which occasional small hæmorrhages may occur.

Treatment. **1. Drugs and applications.**—Ergot should be given to diminish the hyperæmia of the uterus and to check the excessive menstruation. Applications of iodine, iodized phenol, or carbolic acid may be made to the interior of the uterus, and the general health should be improved by suitable treatment. Soluble vaginal pessaries or tampons soaked in glycerine are sometimes used. Their rationale is doubtful as far as the corporeal inflammation is concerned.

Curettage.—Where definite infection of the uterine cavity is present, curettage of the diseased mucosa may be effective, the coexistent endocervicitis being treated at the same time, as described on p. 30 *It is necessary, however, to emphasize that where the* cervix alone is infected, curettage of the corporeal endometrium is not only useless but dangerous, for the infection is sure to be carried up into the body of the uterus, and perhaps into the tubes.

Auvard's self-retaining vaginal retractor having been inserted, the cervix is drawn down with two pairs of volsella forceps, and the direction of the uterine cavity ascertained with the sound. Hegar's graduated uterine dilators up to No. 12 are now passed, the cavity is again sounded, in case the wall has been perforated, the curette inserted, and the mucous membrane erased in strips from above downwards. The cervical canal is then scraped with a sharp spoon and the erosion suitably treated (*see* under Endocervicitis, p 30).

When evidence of marked infection is present, especially if gonorrhœal, the operation should be concluded by swabbing out the uterus with a strong chlorine solution; but in gonorrhœa, at all events, great circumspection should be exercised before undertaking the operation at all, on account of the danger of infecting the tubes.

The dangers of curettage are perforation of the uterus either by a dilator or by the curette, and postoperative sepsis, especially salpingitis

Other methods of treatment.—Curettage may fail, or only succeed temporarily. In fibrotic endometritis, and still more in diffuse fibrotic metritis (p. 36), the curette removes nothing, and does little good. In gonorrhœal cases the infection may be very persistent.

In such circumstances the operation may be repeated, and the uterus swabbed out with chloride of zinc (30 gr. to an ounce), or with pure nitric acid applied through a glass tube; but these measures are not without risk. To the same end, superheated steam has been applied with a special apparatus (*atmocausis*); but this also is a proceeding attended with danger.

When severe menorrhagia persists in spite of a thorough trial of styptic drugs and properly performed curettage, and particularly when the curette scrapes hard and rough without removing any appreciable amount of tissue, diffuse fibrotic metritis is probably present. In such cases the abdomen should be opened and the uterus inspected. It may be that a previously unsuspected fibroid will be found. Failing this, the uterus can be incised and the interior seen and felt; small polypi can thus be found which would be otherwise undiscoverable. The endometrium can also be very efficiently curetted, a sharp strong scoop being used; and the wound in the uterus can then be sutured up. If the cavity seems large, "utriculoplasty" (*see* p. 37) can be performed to reduce the size of the menstrual area. Both curettage from above and utriculoplasty may fail to cure menorrhagia. If a certain cure is urgent, hysterectomy should be performed.

PYOMETRA

Distension of the uterus with pus occurs sometimes in senile endometritis, the cervix being stenosed by atrophy. It is also seen in the later stages of cervical carcinoma. The uterus is soft and enlarged, and, viewed from the abdominal aspect, presents a number of dilated capillaries on its surface. Fever and pain may be present, but some cases show very few symptoms. The condition is only discovered on the escape of thick greenish pus when the sound is passed.

Treatment.—Carcinoma, if present, must be eradicated, if possible. In senile endometritis vaginal hysterectomy is the best proceeding, but curettage and strong iodine solution may first be tried.

TUBERCULOUS ENDOMETRITIS

In this rare affection the mucosa is greatly thickened by diffuse cell proliferation, amidst which giant cells are found. The condition is sometimes found post mortem in persons dead of tubercle elsewhere. Often there have been no symptoms. In other cases, irregular bleeding and offensive discharge have led to a diagnosis of carcinoma. Treatment consists in removal of the uterus.

ENDOMETRIAL HYPERTROPHY

Hypertrophy of the endometrium may follow non-infective chronic uterine enlargement and hypervascularity, particularly that caused by myomas. In such cases the mucous membrane exhibits a diffuse overgrowth, differing from that of endometritis in the absence of inflammatory cells. Cervicitis and cervical erosion are not present. A watery discharge more marked after the menstrual period is the characteristic symptom. It comes from the enlarged uterine glands. Menorrhagia is also present. Removal of the thickened mucosa by the curette is indicated if no tumour of the uterus exists. Where a myoma is present, either myomectomy or hysterectomy is called for. Curettage of a myomatous uterus may produce degeneration or infective necrosis of the tumour, and in any circumstances is likely to fail.

FIBROTIC METRITIS (UTERINE FIBROSIS)

A pathological condition of the uterine wall characterized by diffuse fibrous overgrowth and corresponding muscular degeneration. Its causation is not known in all cases, but the most marked examples are secondary to long-continued endometritis. In others it is possibly the ultimate outcome of subinvolution after labour or abortion, whilst in a third group a primary cirrhosis of vascular origin appears probable.

Macroscopically, the uterus is usually somewhat enlarged and very hard, and from its cut surface a number of thick-walled and inelastic vessels project. Microscopically, diffuse fibrosis is seen, especially under and in the endometrium, which is shrunken and hard, and in the worst cases ecchymosed. The vessels have largely lost their muscular tunic, and in places are converted into sinus-like channels without definite coats.

Symptoms.—Profuse and intractable menstrual hæmorrhage from a uterus but slightly enlarged and not deformed is the characteristic symptom. The loss may become almost continuous, and the patient intensely anæmic.

Diagnosis.—Absolute diagnosis is impossible until the uterine cavity has been explored, for similar profuse losses may be caused by intra-uterine polyps, or small sessile myomas or adeno-myomas. In fibrosis the cavity is empty, and the curette scrapes hard and rough on the sclerotic surface. A characteristic feature is the inability of ergot or other styptic drugs to control the hæmorrhage, owing to the degeneracy of the uterine musculature. Many cases are repeatedly and uselessly curetted before the true diagnosis is made.

Treatment.—Hysterectomy is usually necessary, total if the cervix is unhealthy. In doubtful cases a thorough curetting should first be tried.

In young women an alternative to hysterectomy is "utriculoplasty," as practised by Kelly and myself. The operation consists in excising a wedge-shaped portion of the whole thickness of the uterine wall, the base at the fundus and the apex at the internal os, followed by suture of the two moieties to one another, so as to form a miniature uterus or "utriculus." There is a risk, however, of the hæmorrhage returning, which should be explained to the patient before the operation. My first patient had three pregnancies subsequently to the operation.

NEW GROWTHS OF THE UTERUS

CYSTS OF THE CERVIX

Cervical cysts are always inflammatory in origin, and only occasionally attain the size of a walnut. The treatment is that appropriate to chronic cervicitis (p. 30). When large, the cyst should be excised, or the vaginal cervix amputated.

POLYPUS OF THE CERVIX

Pathology.—Four varieties of cervical polypus are found:

1. The *adenomatous polypus* is a pedunculated, very vascular, inflammatory excrescence of the cervical mucous membrane. It is covered with a short columnar epithelium, and presents a number of racemose glands surrounded by a cellular stroma. It is bright red in colour and is never larger than an almond.

2. The *cystic polypus* is similarly derived and constructed, but the glands have undergone cystic dilatation. (Fig. 592.) These polypi, therefore, are much larger, often lobulated, and are pale and semi-translucent in appearance. They are uncommon. Both this and the first variety are collectively known as "mucous polyps."

3. The *myomatous polypus* is a sessile submucous cervical myoma which gradually becomes pedunculated It is hard and pink, and may attain a large size

4. *Sarcomatous polypi* are, fortunately, rare, and such as have been studied have been of the small round-celled or mixed-celled variety. They are soft, irregular in outline, reddish-white in colour, and bleed profusely.

Symptoms.—A glandular cervical polypus gives rise to irregular losses of blood, especially after manipulation or coitus, from the numerous capillaries contained in the tumour. The symptoms of cervicitis are invariably coexistent.

A myomatous polypus of the cervix may cause no symptoms, and is sometimes discovered accidentally, for since the corpus is uninvolved, menorrhagia is not associated with it, as with myomas higher

up. The tumours, when large, may occasion discomfort by their size. They are prone to necrosis, owing to the precariousness of a blood supply conveyed through a narrow pedicle, and may then cause a very foul discharge with constitutional symptoms. They may separate spontaneously.



Fig. 592.—Cystic mucous polyp.
The glands are dilated and full of retained secretion. The columnar epithelium lining them is degenerate.

Sarcomatous polypi give rise to continued bleeding, and later to signs of generalized metastasis.

Treatment.—Glandular and cystic polyps should be evulsed and the cervical canal well scraped with a sharp spoon. Myomatous polyps may also be evulsed if small; otherwise they should be treated by the methods described at p. 63. If the polyp is sarcomatous, radical extirpation of the uterus is indicated.

CARCINOMA OF THE CERVIX

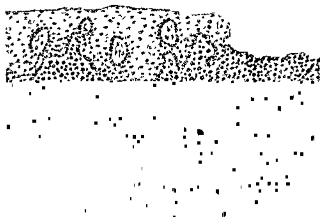


Fig. 593.—Early carcinomatous ulcer of the cervix.

Etiology.—Carcinoma of the cervix is commonest between the ages of 40 and 50. It is very rarely seen before 30, and occurs with lessening frequency from 50 up to old age.

The disease bears a remarkable relationship to

childbearing, and is most uncommon in virgins. This is due to the fact that carcinoma of the cervix is superimposed on cervical "erosion."

Pathology.—Two forms of carcinoma are met with in the cervix, the squamous-celled and the columnar-celled. The first is by far the more common, the malignant epithelial cells being derived from the interpapillary down-growths of the hypertrophied epithelium that covers the erosion. (Figs. 593 and 594.) It is in the third stage of an erosion that carcinoma is most likely to occur (*see* p. 29). The columnar-celled growth is derived from the glandular elements of the cervix, and represents about 2 per cent. of the total number of cases

Histologically, the squamous-celled type presents a number of masses of oval cells closely packed in alveolar spaces between the cervical tissues. These cells usually show no tendency to keratinize, and cell nests are uncommon. (Fig. 594.)



Fig. 594.—Squamous-celled carcinoma of the cervix.

The cells lie in masses closely packed. There is no keratinization or cell-nest formation in this specimen.

From the primary growth extension occurs both by lymphatic permeation and by infiltration. The lymphatic tract first affected, as a rule, is that extending outwards below the uterine artery towards the pelvic wall, from which it ascends via the glands in the obturator fossa to communicate with the lymphatics and glands along the inner side of the external iliac vein.

The glands named, together with others irregularly scattered in the broad ligament, are, therefore, the earliest affected by metastatic growth. It is, however, remarkable that in more than half of the patients dying of the disease no glandular involvement is found on autopsy (Leitch) In this respect, therefore, carcinoma of the cervix is much less malignant than carcinoma in many other parts of the body. Glandular enlargement, when found, is not necessarily carcino-

matous, for the invasion of a lymphatic gland by carcinoma is preceded by inflammatory enlargement.[1] Metastatic growths other than those in lymphatic glands are rare.

Infiltrative growth, as opposed to permeation of trunk lymphatics, occurs in several directions. *Anteriorly, the vaginal vault and the* bladder become in time involved. Posteriorly, extension occurs along the utero-sacral folds, the posterior vaginal vault, and the recto-vaginal septum. Laterally, the carcinoma spreads into the cardinal ligaments and paracervical and paravaginal cellular tissue, at first

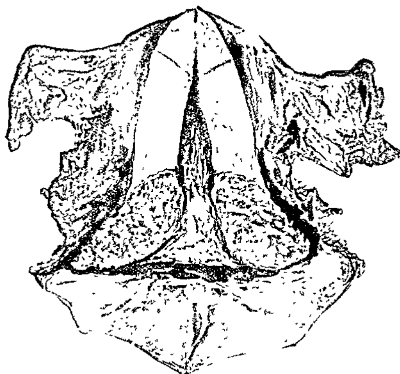


Fig. 595.—Carcinoma of cervix, *fungating type. Removed by the* radical abdominal operation.

displacing the ureter outwards and subsequently involving it Downwards, the growth involves the vagina.

The disease, even in the latest stages, practically never extends above the internal os. In advanced cases chronic salpingitis is usually found, due to ascending infection. Pyometra is not uncommon.

Symptoms.—The earliest symptom *in most cases is hæmorrhage,* at first slight or intermittent, and provoked by coitus, examination, or douching, but later continuous, and sometimes very free. Discharge other than blood is then noticed; it is watery in character,

[1] *See* the author's Hunterian Lectures, R.C.S., 1900.

and usually peculiarly offensive. Occasionally it may be the first symptom. Pain usually supervenes later, is of a continuous gnawing type, and is referred to the lower part of the back and thighs, whilst micturition is both painful and frequent.

Where the hæmorrhage is severe, great anæmia follows, but, apart from this, most patients present more or less cachexia. Occasionally, however, the face is fat and ruddy, almost to the close. In the later stages of the disease, fistulæ form between the vagina and the bladder and rectum. Death is due most commonly to suppression of urine, following blockage of both ureters and bilateral hydronephrosis; in other cases, to exhaustion from loss of blood, or to toxic absorption.

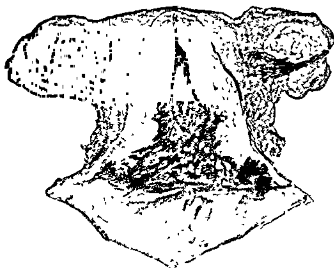


Fig. 596.—Carcinoma of cervix, ulcerative type. Removed by the radical abdominal operation.

The duration of the disease, *from the earliest symptoms to death*, in patients unoperated upon, is on an average one year and nine months (Leitch). Its progress is much slower in old women than in the young.

There are four common **clinical types** of the disease:

(1) In the *fungating* variety the growth forms a large irregular excrescence which, sprouting from the cervix, fills the vaginal vault ("*cauliflower excrescence*"). The bleeding is usually profuse, but the tendency to infiltration and lymphatic permeation is less than in the other varieties. (Fig. 595.)

(2) The *ulcerative* form presents as a deep excavation with rugged and friable sides, occupying the position of the cervical canal. In these cases the discharge is particularly foul. *(Fig. 596.)*

(3) In the *massive infiltrative* type the vaginal cervix is much

enlarged and indurated. Little can be seen on inspection, but blood persistently oozes from the external os, and the cervix feels heavy as though made of lead.

(4) In the *senile atrophic* variety the vaginal cervix has disappeared, and is replaced by a depression at the top of the vagina, from which blood oozes. No mass or ulcer may be felt, and the real condition is easily overlooked.

Diagnosis.—When the disease is well established, the freely bleeding friable mass, fungating or excavated, can scarcely be mistaken. The massive infiltrative form is more difficult to diagnose. The size and induration of the cervix, not less than its tendency to bleed, should awaken suspicion. Allusion has already been made to the slight physical signs of the senile atrophic form.

A quite early case of carcinoma of the cervix is rarely seen. Such cases present either a small reddish nodule or an irregular ulcer, difficult to distinguish from the "erosion" on which the growth is beginning.

The surface of an erosion, though perhaps irregular and hard, is never friable, and though it may sometimes be made to bleed by rough handling, yet any pronounced tendency to hæmorrhage immediately suggests carcinoma. The diagnosis of early cervical carcinoma is often impossible without the aid of the microscope. Therefore, all suspicious cases should be immediately examined under an anæsthetic and a portion of the suspected tissue removed for investigation. The comparative rarity with which patients seek advice in the early stages of the disease is due to their ignorance of the significance of irregular uterine hæmorrhage. The popular delusion that the premenopausal period is normally associated with excessive or continued bleeding cannot be too strongly combated, nor the idea that the absence of pain negatives a malady of any importance. It is, further, of the highest necessity that practitioners should insist on a vaginal examination before treating any case of genital hæmorrhage.

Treatment.—*All cases in the operable stage should be promptly* dealt with by surgical measures. The disease may be attacked from the vaginal or the abdominal route.

Vaginal hysterectomy. *Standard of operability.*—Simple vaginal hysterectomy is only applicable when the growth is limited to the cervix, when enough of the cervix remains to get a hold upon, and when the uterus is sufficiently movable to permit of its being pulled well down towards the vaginal outlet. Induration at the base of the broad ligaments or utero-sacral folds, or extension of the growth on to the vagina, bars the operation.

Not more than 15 per cent. of the cases are seen in this early stage.

The operation.—The growth having been scraped and cauterized, and the limit of the bladder on the vaginal vault ascertained, the

mucous membrane covering the cervix is circumcised at its junction with that of the vault. The bladder is then separated from the supravaginal cervix by scissors and swab pressure until the peritoneum at the bottom of the utero-vesical pouch is reached. This is then opened. The cervix being now pulled forwards, the utero-rectal pouch is opened behind it. The uterus is then pulled down and, the pulsations of the uterine artery having been defined, the base of either broad ligament is transfixed above the vessel, ligatured, and divided. The uterus, now much more mobile, is pulled farther down, and the upper part of the broad ligament with the ovary, ovario-pelvic ligament, tube and round ligament on either side is included in a couple of ligatures and divided. The vaginal vault is partly closed, and the aperture remaining into the peritoneal cavity lightly plugged with gauze.

When access to the upper part of the broad ligaments is difficult, it may be facilitated by anteflexing the uterine body. Sometimes it is better simply to clamp the broad ligaments in sections before dividing them, and to apply the ligatures afterwards.

Advantages and disadvantages.—The advantages of vaginal hysterectomy are its ease in most cases, and its low mortality (about 6 per cent.) But not more than 15 per cent. of the cases are suitable, and of these a very large proportion suffer from recurrence within a year.

Radical hystero-vaginectomy by paravaginal section. *Standard of operability.*—Access to the pelvis from below can be much facilitated by performing paravaginal section. This consists in making an incision along the junction of the left lateral and posterior vaginal walls, which, dividing the skin of the perineum on the left side, sweeps round the rectum towards the coccyx. The anterior fibres of the left levator ani are severed and a large gap is effected, through which a much more extensive operation is possible.

It is better in carcinoma of the cervix to remove the whole vagina with the uterus, and in this case it is first separated from the skin and its end sewn up so as to exclude the disease from the area of the operation. It is then dissected free of the bladder in front, the rectum behind, and the cellular tissue laterally, before the paravaginal section is performed.

The remaining steps are similar to those of vaginal hysterectomy, except that the ureters are clearly defined and pushed aside, so that the bases of the broad ligaments may be ligatured and divided far out towards the pelvic side wall.

Advantages and disadvantages.—By paravaginal section about 40 per cent. of the cases are operable. Infiltration of the vaginal vault or moderate extension into the base of the broad ligaments or utero-sacral folds does not contra-indicate the operation, but extension to the bladder or rectum or massive infiltration around the ureter

renders it impossible. It has the disadvantage that it is impossible to examine the regional glands until the operation has been practically concluded, and in any event they cannot be removed by this route.

The immediate mortality is somewhat lower than that of the radical abdominal operation, but the convalescence is protracted, the deep hole which is left taking weeks to granulate up, and frequently sloughing badly.

Radical abdominal hystero-vaginectomy (Wertheim's operation).—This operation aims at removing the uterus, together with the upper third or half of the vagina, in such a way that the cervix is encapsuled by the latter, across which a clamp has been placed before amputation. Together with the uterus are also removed the appendages, broad ligaments, and as much as possible of the pelvic cellular tissue and regional glands.

Standard of operability.—So long as the growth has not extensively involved the bladder or rectum, or absolutely fixed the uterus in the pelvis, its removal is possible by this method. That the cervix cannot be pulled down is of no moment, if it can be pushed up.

It is often impossible to be certain that the fixation of the uterus is due to carcinomatous infiltration, because similar physical signs may be produced by the chronic salpingitis which commonly accompanies advanced growth. In estimating the degree of involvement of the bladder or ureter, the cystoscope may prove useful. In cases of doubt, examination under an anæsthetic is advisable, and if the possibility of eradication is still undecided the abdomen should be opened and the condition explored from above.

By Wertheim's method between 50 and 65 per cent. of all the cases seen are operable, according to the views of the individual surgeon.

The operation.—The growth, if fungating, should be thoroughly scraped, but otherwise it is best to let it alone. The vagina should be firmly packed with gauze soaked in the aniline antiseptic "violet green." This is the most efficient way of rendering the vagina and growth aseptic, whilst in addition it makes the subsequent separation of the bladder and rectum much easier. The gauze is withdrawn just before the vagina is cut across. The abdomen is then opened, and the ovario-pelvic and round ligaments on either side are ligatured, and divided at the pelvic brim. The peritoneum is now incised across the front of the uterus at the limit of its loose attachment, and by thumb pressure, aided by cautious snips, the bladder is pushed off the supravaginal cervix and the upper half or two-thirds of the anterior vaginal wall in the middle line.

The ureter of one side is now felt for, as it runs in close attachment to the posterior peritoneum of the broad ligament, and its direction

onwards having been ascertained, the uterine artery is sought outside this line, is lifted by pressure-forceps, and is divided and ligatured as far outwards as possible. By tracing the distal portion of this vessel inwards the point at which it crosses the ureter is attained. From this point onwards the ureter is separated up to its entry into the bladder. Care must be taken not to injure the periureteral sheath. The other ureter is then similarly treated.

The uterus being pulled well forwards, the peritoneum at the bottom of Douglas's pouch is incised and the rectum separated from the vagina. The utero-sacral folds are then divided, the ureter being protected by the fingers during the process. The uterus is still tethered by the strong cardinal ligaments of the vagina that sweep out on either side under the ureters like a pair of buttresses (*see* p. 18). The ureters being held out of the way, these ligaments are divided. The uterus riding up, the bladder is still further separated

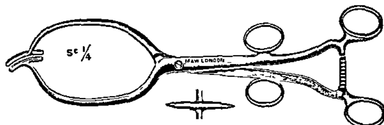


Fig. 597.—Berkeley-Bonney vaginal clamp.

from the vagina until the latter can be clamped well below the limit of the growth For this purpose the Berkeley-Bonney vaginal clamp (Fig. 597) will be found the most convenient. The vagina is divided below the clamp either with the cautery knife or with a scalpel. All bleeding-points and previously-clamped tissues are ligatured, and the operator then proceeds to suture the open end of the vagina. The next step is to ablate such of the parametric and paravaginal tissue as has escaped removal with the uterus. The most important part of this is a sheet of tissue against the side wall of the pelvis, at the upper border of which runs the obliterated hypogastric artery. Behind this sheet are the obturator fossa and the glands there. The whole of these should be removed. The glands along the iliac arteries are stripped off, whether enlarged or not, by incising the soft tissue which covers the external iliac vessels parallel to and outside the main artery, and reflecting the tissue inwards from off the external iliac vein and the brim of the pelvis. The fingers are then pushed down between the soft tissue and the bony side wall of the pelvis, the tissue mass, which contains both the external iliac and obturator glands, being pushed inwards. The obliterated hypogastric artery is

excavated by a diffuse ulceration, the surface of which is irregular and friable. Microscopically the neoplasm is most often a columnar-celled adeno-carcinoma (Fig. 599), but in senile patients, in whom the corporeal epithelium has undergone degenerative flattening, a keratinizing squamous-celled growth may occur. Lymphatic permeation follows the course of the ovarian vessels, and primarily reaches the lumbar and aortic glands.

Symptoms.—Persistent hæmorrhage and watery discharge are first noticed, but pain is often an early symptom. Cases are not uncommon in which advanced growth is accompanied merely by occasional slight losses of blood, and sometimes by no bleeding at all. Fetor

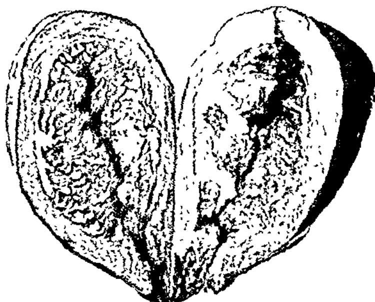


Fig. 598.—Fungating type of carcinoma of the body of the uterus.

occurs relatively later than in cervical carcinoma. On examination the uterus may be found moderately enlarged and soft, whilst in many cases the cervix is so patulous that the finger passed through it detects the soft growth above. In other cases, however, the diagnosis can only be established after dilatation of the canal, digital exploration, and removal of a portion of tissue for microscopical examination.

Later, diffuse peritoneal and omental metastasis occurs, or the patient succumbs to massive growth in the upper lumbar glands or multiple nodules in the liver or lungs. In either case, irregular nodules and lumps will be felt through the abdominal wall.

Diagnosis.—Corporeal carcinoma is not the commonest cause of postmenopausal bleeding, but is next in frequency to carcinoma

of the cervix. Senile endometritis sometimes gives rise to slight irregular hæmorrhages, but the discharge is principally pus. It is, however, to be remembered that this form of endometritis is the common precursor of carcinoma of the corpus Before the menopause patients are apt to attribute the symptoms to that event; the fatal results of this error have already been mentioned (*see* p. 42). The diagnosis may be obscured by the presence of a uterine myoma, but continuous loss is not characteristic of these tumours. All cases of persistent hæmorrhage about or after the menopause should be immediately investigated, the uterus being explored under an anæsthetic if necessary; and the same should hold for any bleeding, even though quite occasional, after the menopause.



Fig. 599.—Columnar-celled tubular carcinoma of the body of the uterus.

The tubules are irregular, and in many the epithelium is several cells thick.

Treatment.—If there is no evidence of metastatic growth the entire uterus with both appendages should be immediately removed, and the leash of ovarian vessels on each side ablated as high up under the posterior peritoneum as possible, for the lymphatics most likely to be the seat of cancer-cell permeation accompany them. This operation is best accomplished through an abdominal incision, but in very stout women, with a uterus scarcely or not at all enlarged, the vaginal route may be chosen.

The after-results of hysterectomy for corporeal carcinoma are far better than those for cervical carcinoma

For inoperable cases the treatment is similar to that for inoperable carcinoma of the cervix (p. 47), except that radium is not so easily applied; indeed, if the fixed mass be a large one, better results will be obtained by heavy doses of X-rays.

CHORION-EPITHELIOMA

This rare and interesting growth is derived from the fœtal trophoblast. It usually follows abortion or labour after an interval of but one or two months, but occasionally does not declare itself for a much longer period. It is peculiarly associated with vesicular moles, and all gradations between that condition and pure chorion-epithelioma have been found. Though usually primary in the uterus, it has originated



Fig. 600.—Chorion-epithelioma, showing syncytia and Langhans' cells.

in the tube after tubal gestation. A number of cases are also on record of primary vaginal growth, elements of the trophoblast having migrated there from the gestation site and initiated the tumour. Its occurrence in teratomas will be referred to later (p 98).

Pathology.—The tumour has a characteristic deep blood colour. Microscopically it presents three types of cell—(1) closely set hyaline mononucleated cells identical with the Langhans cells of the normal chorionic villus; (2) larger cells of the same type laden with granules; and (3) large multinucleated masses of protoplasm (syncytia) similar to those seen on the periphery of the villus of an early gestation. These

cells are embedded in masses of fibrin and extensive blood extravasations. The microscopic appearance of a chorion-epithelioma (Fig. 600) is exactly that of the tissues at the growing margin of an early gestation, Modern research shows, indeed, that in the process of the embedding of the human ovum its trophoblast acts practically as a malignant tissue, destroying the maternal tissue with which it comes in contact. Normally, this infiltrative power is arrested after the first few weeks

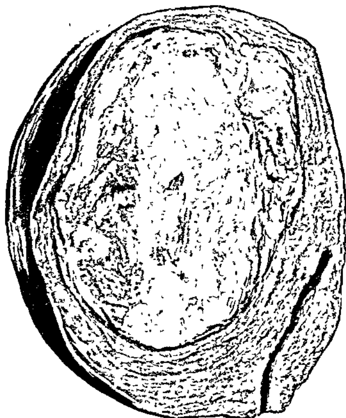


Fig. 601.—Large interstititial myoma undergoing œdematous degeneration.

of the life of the gestation; occasionally, however, it persists and leads to malignant growth

Metastasis occurs with great rapidity, pulmonary nodules being particularly common.

Symptoms and diagnosis.—The symptoms are hæmorrhage, foul discharge, rapid uterine enlargement, and often fever. Inasmuch as in most cases abortion or labour has occurred quite recently, the symptoms simulate those of retention of conception products, but the

they tend to become pedunculated, so that a very large tumour is frequently attached to the uterus by quite a narrow stalk. The uterus is not enlarged by a subperitoneal myoma, but, *inasmuch as it may form* the peduncle of a large tumour, its vascularity may be much increased. (Fig. 602.)

2. Cervical myomas.—About 6 per cent. of all uterine myomas grow in the cervix. These tumours, when large and growing interstitially or under the mucous membrane, cause a very characteristic elevation of the uterine body on the top of them. (Fig. 603.) The cervical canal is immensely elongated, and the broad ligaments and bladder are undermined and stretched. A cervical myoma developing on the front of the cervix (Fig. 604) burrows under the bladder and raises it out of the pelvis; while one growing from its back (Fig. 605) may undermine the peritoneum at the bottom of Douglas's pouch and gradually obliterate the pouch altogether. Cervical myomas growing laterally invade the broad ligament.

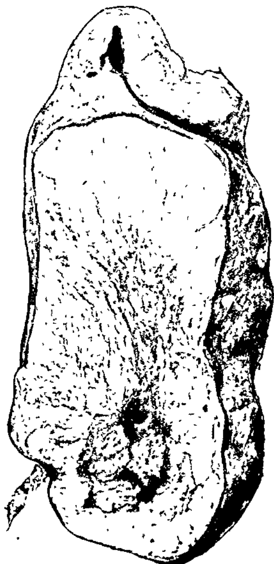


Fig. 603.—Typical central cervical myoma. The body of the uterus is raised on the tumour.

3. *Broad-ligament* myomas.—Tumours growing laterally from the side of the corpus or cervix expand the broad ligament. These are not truly *of* the broad ligament. There are several tracts of unstriped muscle in the mesometrium from which true broad-ligament tumours may

originate. (*Fig.* 606.) Thus, myomas of the ovario-uterine and round ligaments occur. Others are found occasionally springing from the muscle-fibres that accompany the ovarian or uterine vessels. These may attain a large size, and, after distending the broad ligament to its fullest capacity, mount up into the abdomen by stripping the peritoneum off its posterior and lateral parietes. The pelvic colon thereby comes to lie sessile on the mass, while the uterus is forced to the opposite side. The ureter is displaced inwards with the peritoneum, except in the rare cases of lateral cervical myomas growing very low down, when it may be raised bodily on the top of the tumour.

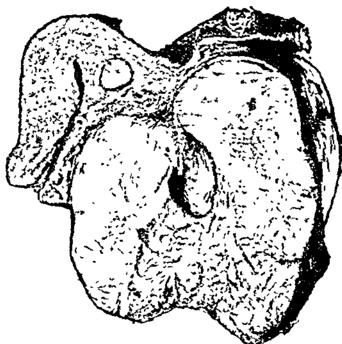


Fig. 604.—*Anterior cervical myoma undermining the peritoneum of the utero-vesical pouch. A small interstitial tumour is also present.*

Pathology.—A uterine myoma in its earliest stage presents as a little white nodule embedded in the musculature. Structurally, it consists of densely interlaced unstriped muscle fibres united by some connective tissue. (*Fig.* 607.) It contains but a few small vessels, derived from the adjacent uterine wall, which surrounds the tumour in concentric layers and forms its capsule.

As the tumour enlarges, the uterine wall around it hypertrophies, and assumes the stratified appearance which characterizes the musculature of the pregnant uterus.

The microscopical structure of a "normal" myoma is identical with that of the muscular uterine wall itself, except that it does not contain considerable vessels. Such a tumour takes years to attain large size.

Owing probably to their poor vascular supply, myomas are particularly prone to degenerate; to this more than to any other factor the serious symptoms are due.

These degenerations must be considered in detail, as follows :—

Fibrotic degeneration.—Characterized by increase in the white fibrous elements of the tumour and disappearance of the muscle tissue. The tumour becomes very white and hard, and ceases to grow (*fibro-myoma*).

Calcareous degeneration.—Usually a senile change. The calcific deposit may begin centrally or peripherally. The tumour becomes stony hard and, of course, ceases to grow. The change is most apt to affect pedunculated *subperitoneal tumours in old age*, and is not entirely beneficent, for the rough surface may set up chronic peritonitis around it.

Œdematous degeneration.—An œdematous swelling affects the interstitial connective tissue, and the muscle-fibres degenerate. The tumour becomes pulpy and soft, and rapidly enlarges (*see* Fig. 601).

Myxomatoid degeneration.—This is by some regarded as an advanced stage of the last form. Centrally, the tumour is converted into a yellow-green jelly-like substance. True mucin is not present.

Cystic degeneration.—This, again, is probably a further stage of softening. Usually only one cavity is present, but there may be several. When the change is complete the resemblance to an ovarian cyst is considerable. (Fig. 608.)

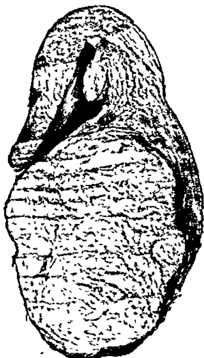


Fig. 605.—Posterior cervical myoma. The uterus also contains a small submucous polypoid myoma.

All the last three forms of degeneration are frequently accompanied by chronic peritonitis in the neighbourhood of the tumour.

Red degeneration.—The tumour here exhibits varying tints, from pink up to mahogany-brown. The change has been considered due to thrombosis of the vessels supplying the area, and therefore analogous to "red" infarction. The coloration, however, is due to free blood-pigment, and it is often intensified on exposure to the air. The process is probably due to the development in the tumour of some toxin which not only causes acute necrobiosis of its substance but

also produces lysis of the red blood-corpuscles. The degeneration has frequently been recorded in connexion with pregnancy, and is characterized by the sudden onset of pain in the tumour. Fever is usually present.

Nævoid degeneration.—Occasionally a myoma becomes very



Fig. 606.—Broad-ligament myoma, with the uterus, unenlarged, to the right.

vascular, a number of *thin-walled blood-spaces developing in the* tumour. The vessels of the tumour capsule in particular become very large, and the whole uterus is at last covered with large varicosities. These tumours grow very fast, and enlarge at each menstrual period; on auscultation a murmur is heard over them. The general likeness to pregnancy is often considerable.

"Caseous" degeneration.—A rare change, in which the myoma undergoes a transformation into a substance resembling adipocere. This is not a true caseation.

Sarcomatous degeneration.—About 2 per cent. of all myomas are said to undergo sarcomatous change. Myo-sarcoma, round-, spindle-, and mixed-celled sarcoma, angio-sarcoma, and endothelioma are all on record. The prognosis of these transformed myomas is better than that of primary sarcomas.

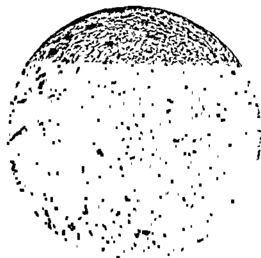


Fig. 607.—Uterine myoma, consisting almost entirely of unstriped muscle-fibres running in various directions.

Carcinoma of a myomatous uterus.—There is a considerable amount of evidence showing that myomas predispose to the development of corporeal carcinoma, but cervical carcinoma complicating a myomatous uterus is relatively rare. (Fig. 609.)

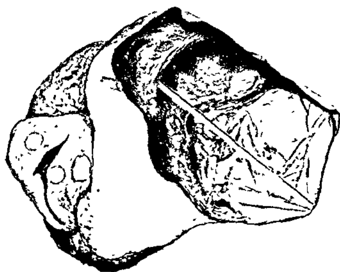


Fig. 608.—Broad-ligament myoma that has undergone *cystic degeneration.* The uterus is pushed to the left, and contains several smaller tumours.

Symptoms.—The symptoms of uterine myomas may be divided into four groups—(1) menstrual symptoms, (2) pressure symptoms. (3) degeneration symptoms, and (4) symptoms due to certain complications and accidents.

1. **Menstrual symptoms.**—*Menorrhagia is the most constant symptom.* It is due partly to the increased size of the menstrual area, partly to the augmented vascularity of the uterus, and partly

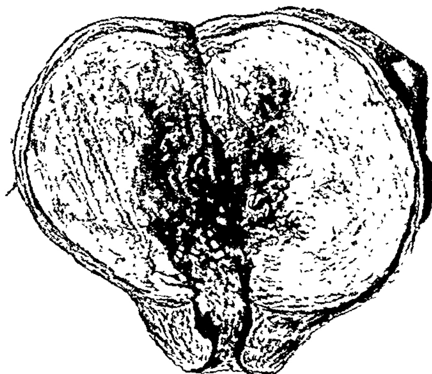


Fig. 609.—Carcinoma of the body of a myomatous uterus.

to unknown causes. For the menstrual period *is increased not only* in quantity and duration, but often also in frequency, and, further, a small submucous nodule may produce hæmorrhage far in excess of that caused by a much larger mass in exactly the same position in another patient. The menorrhagia usually begins insidiously and steadily increases. Patients have generally so suffered for some years before seeking advice.

Submucous myomas produce the most severe loss, while the subperitoneal variety may cause no alteration in the periods, the uterus proper not being enlarged. Menorrhagia with a large subperitoneal myoma suggests the coexistence of a small submucous nodule. Cervical myomas are, however, often associated with very severe loss, although they do not involve the menstrual area proper.

Patients thus afflicted become very anæmic, and eventually develop cachexia associated with breathlessness and cardiac degeneration. Dysmenorrhœa is not a common symptom. When present it is of the obstructive variety, and consists in violent spasms of pain associated with the passage of clots from the uterus.

2. **Pressure symptoms.**—These, when severe, are generally due to impaction of the tumour in the pelvis. Cervical myomas are particularly prone to this complication. A myomatous uterus, like a pregnant one, may become retroverted and incarcerated.

The bladder is usually the first organ to exhibit symptoms of pressure, generally in the form of frequency of micturition; retention is less common and, when present, implies impaction.

Pressure on the ureter is much rarer than might be supposed, but in cases of prolonged impaction these conduits are found dilated.

The bowel is less frequently occluded by pressure than by kinking due to displacement or adhesions. Partial intestinal obstruction is not uncommon, but acute symptoms are rare.

Very large tumours may press upon the vena cava and produce œdema of the legs, or may distend the abdomen sufficiently to embarrass respiration.

3. **Degeneration symptoms.**—One feature alone is common to most degenerated myomas, i.e. tenderness supplants the insensitiveness of the "normal" tumour. If the degeneration be œdematous, myxomatous, or cystic, the tumour rapidly increases in size. The sudden onset of pain characteristic of red degeneration has already been mentioned (p 56). In many forms of degeneration more or less fever is manifested.

The supervention of carcinoma in the body of a myomatous uterus is characterized by the hæmorrhage becoming continuous instead of periodic.

Sarcomatous degeneration is accompanied by severe hæmorrhage, rapid bossy enlargement of the tumour, ascites, and emaciation.

4. **Symptoms due to complications and accidents.**—*Inflammation* of a myoma is usually caused by infection from the uterine cavity. This very serious complication especially follows labour and abortion, and presents the signs of acute local peritonitis, which later may become generalized. An infected myoma usually undergoes necrosis, and, if submucous, may slough out.

Salpingitis is a common complication, and produces its usual symptoms. It is, as a rule, of the chronic type, the tubes being thickened or distended with clear fluid. Occasionally, owing to regurgitation of menstrual blood, a double hæmatosalpinx is present, and especially with cervical myomas. Pyosalpinx is less frequent (*see* p 74)

Ovarian cysts so frequently complicate uterine myomas that no wise diagnostician would often pledge himself that the ovaries were undoubtedly sound. Many masses thought to be purely myomatous are found at operation to be partly ovarian, and vice versa.

Extrusion of a myoma is commonest with a polypoid submucous tumour, but may follow injury or ulceration of the capsule of a sessile one, and is then a septic process from the beginning. Extrusion produces severe, painful, colicky, uterine contractions and free hæmorrhage, accompanied, if the tumour be infected or sloughing, by fever and foul discharge. (Fig. 610.)

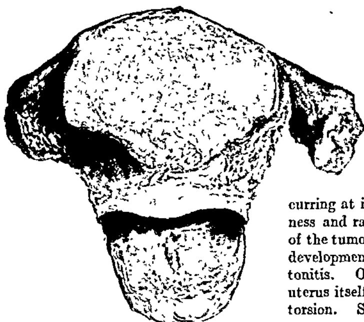


Fig. 610.—Submucous myoma in process of extrusion.

Axial rotation of a pedunculated subperitoneal myoma is characterized by sudden violent pain recurring at intervals, tenderness and rapid enlargement of the tumour, and the early development of local peritonitis. Occasionally the uterus itself partakes in the torsion. Such cases present severe shock and profuse external bleeding.

The *supervention of pregnancy* varies in its results. A subperitoneal tumour of moderate size permits a normal termination of gestation. Interstitial tumours show apparent rapid growth, largely due to hypertrophy of the pregnant uterus round them; the net increase in bulk may suffice to produce pelvic impaction or great abdominal distension.

A submucous tumour strongly militates against pregnancy, but if this occurs abortion is probable.

A cervical myoma or a pedunculated subperitoneal mass that has gravitated into the pelvis will obstruct labour, and sessile fundal tumours not infrequently, by their weight, retroflex the soft pregnant uterus and cause incarceration. During the lying-in period a "fibroid" may be extruded or may slough out; while puerperal sepsis affecting a myomatous uterus is a grave disaster.

Physical signs.—The physical signs of a myoma vary with its position. Its connexion with the uterus is usually obvious, but pedunculated subperitoneal tumours may appear to be entirely separate. Submucous tumours enlarge the organ uniformly, while those nearer the peritoneal surface stand out as bosses or knobs. A cervical myoma, if interstitial, produces a typical expansion of the cervix like that of the later months of pregnancy; if submucous, its lower pole may be felt through the external os. Anterior and posterior cervical myomas displace the cervix backwards or forwards, while those in the broad ligament carry the uterus bodily upwards and towards the opposite side. The palpability of a myomatous uterus from the abdomen depends upon the size and position of the tumour. Except in broad-ligament myomas, the swelling is usually central. Cervical myomas, even when large, may not be apparent from above. The abdominal tumour is usually dull on percussion, but that produced by the cervical variety may be partly resonant because the intestines are lifted on the mass. Auscultation may reveal a *souffle*, especially when the uterus is very vascular, as in nævoid degeneration. The sound is produced in the vascular leashes of the broad ligament, and is heard to the sides of the mass.

Diagnosis.—If the tumour is obviously connected with the uterus it only remains [illegible] from the enlargements due to [illegible] congenital hæmatometra, and [illegible] *ncy* can only arise during the early months. Although the fact that amenorrhœa practically never occurs with a myoma unless pregnancy coexists is generally distinctive, immediate diagnosis may be obscured by a false menstrual history, or by the irregular hæmorrhages so often associated with early pregnancy.

In such a case, unless the symptoms are urgent, the surgeon may either watch the rate of tumour growth for a month or two, or place the patient under observation to ascertain beyond doubt the presence or absence of the menses.

Carcinoma of the corpus may produce uterine enlargement comparable with that due to a small submucous myoma, but continuous loss and watery discharge replace the periodic floodings. A sloughing myoma during extrusion may closely simulate malignant disease, but on palpation is firm and hard, quite unlike the friable, almost pulpy, feel of carcinoma. It is to be remembered that carcinoma corporis and myomas frequently coexist, and that the latter very rarely *begin* to give trouble after the menopause.

Pyometra is often due to carcinoma, but in cases secondary to senile endometritis a small sloughing myoma may be simulated. There is, however, little or no bleeding in such cases, and the passage of a sound under anæsthesia decides the diagnosis.

Congenital hæmatometra could only simulate a myoma affecting one horn of a double uterus.

The enlargement and severe periodic hæmorrhages due to *fibrotic metritis* cause close resemblance to a small submucous myoma. In this and the previous case the history and age of the patient may decide, but the diagnosis can often only be clinched by exploratory operation.

If a uterine connexion of the tumour cannot be ascertained, absolute diagnosis is impossible. A myoma may then be mistaken for an ovarian tumour, or for the mass formed by an old hæmatocele, chronic salpingitis, or cellulitis.

Scanty menstrual loss, fluctuation, a smooth contour, and comparatively rapid growth strongly favour a diagnosis of ovarian cyst. The swellings due to encysted blood or inflammatory products are usually distinguishable by their history. The importance of passing a catheter in any case of a doubtful abdomino-pelvic tumour cannot be insisted upon too often.

Prognosis.—Once a myomatous uterus has begun to cause symptoms, no material respite can be expected until the menopause. It must be remembered, however, that myomas postpone this event by several years. At the menopause the patient will be relieved of the blood loss, but symptoms dependent upon the bulk of the tumour, its degenerations and accidents, are especially liable to supervene about this time. If these dangers are escaped, the tumour gradually shrinks, though it probably never entirely disappears. The likelihood of carcinoma developing is always present. Although rarely fatal *per se*, a myoma indirectly shortens life by the progressive deterioration of health which the excessive blood-loss produces. In particular, cardiac degeneration is common. A myomatous uterus usually leads to chronic invalidism, but occasionally it directly menaces life from excessive bleeding, obstruction to the functions of vital organs, toxic or septic absorption, or the supervention of malignant growth.

General remarks as to treatment.—A small myoma *causing no symptoms and discovered accidentally may be let alone, if* the patient is elderly.

Where symptoms indicate treatment, two chief methods present themselves, medicinal and surgical.

If menstrual hæmorrhage is the *only* symptom, ergot and other styptic drugs may control it. The adoption of non-operative measures must be considered—(*a*) where, in the absence of urgent symptoms, the patient expresses strong repugnance to operation; (*b*) where the menopause is approaching, and moderate hæmorrhage is the only symptom; and (*c*) where operation is undesirable on account of cardiac, pulmonary, or other disease.

If, however, the bleeding is severe or the patient's social position interferes with the régime imposed by medical treatment, operation should be advised. Again, if the climacteric is several years distant, medical treatment is contra-indicated, for, apart from the life of invalidism to which the patient is condemned, the habitual exhibition of ergot exercises a deleterious effect on the heart and vessels. Symptoms due to pressure, to degeneration, or to any of the accidental occurrences to which these tumours are liable indicate immediate resort to surgery.

Pregnancy is undesirable, except when the myoma is small and subperitoneal; moreover, conception is unlikely and dangerous in a myomatous uterus; therefore removal of the tumour is usually advisable in the case of a patient who wants to have children.

Medicinal treatment.—Ergot is the most satisfactory drug for controlling the menorrhagia. The liquid extract (20 to 30 minims three times daily), combined with strychnine and a dilute acid to exalt its effect, should be administered from a few days before the onset of the flow to its end, and then stopped. Sometimes it gives rise to severe uterine-contraction pain, and may be refused on this account. Should ergot fail, hydrastis and hamamelis may be tried in doses of 15 and 30 minims of the liquid extract and tincture respectively. The hydrochloride and phthalate of cotarnin (stypticine and styptol) may also give satisfactory results. At the time of the period the patient should rest in bed; after it is over, iron in some readily absorbable form should be administered. The treatment of myomas by various forms of electricity has deservedly fallen into disrepute.

Surgical treatment.—The ideal treatment of a myoma is the removal of the tumour with conservation of the uterus. Collected statistics show that myomectomy is practically as safe an operation as hysterectomy, but that it sometimes fails to cure the menorrhagia because (1) a much hypertrophied uterus may be left behind; (2) a small submucous tumour may be overlooked and keep up the excessive loss; and (3) in certain cases new tumours might subsequently develop. At this possible cost is gained the sentimental advantage of continued menstruation and the undoubted advantage of possible pregnancy. The writer has of recent years become a strong advocate of myomectomy in all cases in which conservation of the uterus also conserves the potentiality of childbearing—that is to say, in all women under 40 years of age and many between 40 and 45. The technique of the operation is now so much improved that it is possible to enucleate twenty or more tumours with, in most cases, no more risk than removal of the uterus would entail.

Myomectomy, then, is to be preferred to hysterectomy (1) where the operation, though equally efficacious, is associated with less

risk, as in small solitary submucous tumours causing hæmorrhage, or subperitoneal masses causing pressure or degeneration symptoms; (2) where, on account of the patient's age and social state, the possibility of future pregnancy justifies an attempt to conserve the uterus, even at a somewhat increased risk; (3) where the patient strongly desires the attempted conservation of the uterus after the possible increased risk has been explained to her.

Abdominal myomectomy.—If the tumour is pedunculated, it may be removed by simple ligature of the pedicle in sections. If the tumour is sessile, or its pedicle too massive, it should be enucleated; the bleeding from the capsule is controlled by under-running with mattress sutures, and the peritoneum closed over the uterine wound with Lembert stitches. Interstitial and submucous tumours should be enucleated. The great secret of success in performing multiple enucleation is for the operator to remove all the tumours through a single incision in the anterior uterine wall, getting at tumours not in the line of this by secondary sideway incisions through the musculature.

The risk of myomectomy is postoperative oozing from the uterine incision, which may result in death from hæmorrhage or from intestinal obstruction by coils of intestine becoming adherent to the clot-covered uterus. It is for this reason that a posterior incision is so dangerous. When the suture line is on the anterior uterine wall. any oozing, if it occurs, collects between the uterus and the bladder; and moreover, as an additional measure of precaution, the surgeon can ventrofix the sutured uterine incision to the anterior abdominal wall. I have enucleated as many as thirty tumours through one primary incision. A most thorough search should be made for small "seedling" tumours, for if one is left behind it may grow, and in all cases in which menorrhagia is one of the symptoms the uterine cavity should be opened to make sure that no polypus or small submucous fibroid be left behind. The incision in the uterus should be closed by mattress sutures of stout silk and a continuous catgut suture along the peritoneal edges. Absolute hæmostasis, as far as it can be effected, is essential. A well-sutured uterine incision should show a degree of blanching of the sutured tissue.

The operation is a more difficult one than hysterectomy when the tumours are large, vascular, and numerous, and demands for its safe performance great experience and complete command of the operative technique required.

Vaginal [illegible]
easily be evu[illegible]
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not larger than a bantam's egg, can be enucleated and removed through the cervix, their capsule having been first divided. Occasionally these

tumours will not enucleate owing to capsular adhesions, and adenomyomas are never enucleable. Enormous submucous tumours can be removed per vaginam piecemeal ("morcellement") with scissors.

Where a solitary myoma is already in process of extrusion, and especially if it is sloughing, vaginal myomectomy should always be undertaken in preference to hysterectomy.

infected, cause troublesome discharge, or may develop carcinoma; but infection is an avoidable fault of technique, and cervical carcinoma in these patients is unlikely because of their sterility. The conservation of the cervix maintains the integrity of the vaginal vault, while the subtotal operation is always easier than the extirpation of the entire uterus. The following are the most important methods of performing hysterectomy:—

Subtotal hysterectomy.—The uterus having been pulled up through a median incision, a pressure forceps is clamped on the tube and ovario-uterine ligament with its contained ovarian vessels on each side, and a second pair is applied to the round ligaments about an inch from the uterus. The broad ligaments are now divided between the clamps and the uterus as low down as the level of the internal os. A flap of peritoneum on the front of the uterus is then reflected from the upper limit of its loose attachment downwards. The uterine vessels are now in view as they run up either side of the uterus. They are clamped by pressure forceps just above the point where they leave the parametrium to enter the uterus, and the latter is amputated about ½ in. above this line. The uterine vessels on each side are next secured by a ligature which, transfixing the tissue of the cervical stump just within them, is carried round them and tied on their outer side. The clamped broad ligament on each side is transfixed between the forceps holding the ovario-uterine ligament and tube and the round ligament, and the transfixing ligature is divided into two: one half is used to secure the tube and ovarian pedicle with its contained ovarian vessels; and the other, rethreaded on a needle, is inserted as a mattress suture around the round ligament.

Any oozing from the cervical stump may be stopped by one or two mattress sutures. The anterior peritoneal edge is then united to the peritoneum on the posterior aspect of the stump and broad ligaments, care being taken to suture and bury the stumps containing the ovarian arteries and the round ligaments. The operation is concluded by closing the abdominal wound in three layers.

Total hysterectomy.—The steps of the total operation are similar to those just described up to the point at which the anterior peritoneal

flap is turned down. After this the bladder is gently separated by swab pressure from the supravaginal cervix, sufficiently low to expose freely the anterior vaginal wall. The uterine arteries on each side are now clamped just as they enter the uterus, and divided inside the clamps. Below this level lies the tissue in which the cervical branches of the arteries communicate with the lateral vaginal arteries. A clamp is placed on this tissue close to the side of the cervix and parallel to it, and the tissue is divided inside the clamp. The same is then done on the other side. The vagina has now to be opened from the front by a transverse incision, through which the cervix is seized with volsella forceps and pulled forwards and upwards

The surgeon with his scalpel now divides the attachment of the vagina to the cervix all round, keeping close to the cervix for fear of injuring the ureters, and removes the uterus.

The ovarian vessels and round ligaments are secured as previously described. The uterine arteries are ligatured separately. The lateral vaginal vessels exposed just outside the lateral angles of the divided vagina are treated by mattress suture, and the vagina is now closed by a continuous catgut suture.

The anterior peritoneal edge is finally united to the edge of the cut peritoneum on the posterior vaginal wall and broad ligaments, the stumps being buried as in subtotal hysterectomy. The ureters are liable to damage during total hysterectomy unless their course is clearly defined and the bladder wall separated from the upper part of the vagina It is most important to sterilize the vagina before beginning the operation; violet-green is the best antiseptic to use for this purpose. If the uterus is infected or contains a carcinoma the cervix should be closed by suture before the abdomen is opened.

Hysterectomy for cervical myomas.—The technique just described is not proper for cervical myomas. In such cases the spreading of the broad ligaments, the displacement of the bladder, and the fixity of the mass render the ordinary methods of securing the uterine vessels and amputating the uterus impossible. The difficulty in these cases is the control of bleeding during the removal of tumour and uterus, which, therefore, must be accomplished as quickly as possible. The upper part of the broad ligaments having been clamped and divided, the loose anterior peritoneum and the bladder are pushed off the front of the expanded supravaginal cervix as low as possible. The expanded tissue forming the tumour capsule is now divided transversely in the mid-line for about an inch, and by introducing the finger the plane of cleavage between the tumour and the capsule is defined. The incision is then prolonged to either side, and the lower pole of the tumour enucleated from its bed and pulled up. The incision is now extended around the uterus on each side, the uterine vessels being

clamped *en passant.* Subtotal hysterectomy is thus effected, the lower part of the capsule of the tumour (i.e. the expanded supravaginal cervix) being left behind. This is trimmed up or entirely removed, and the vessels are secured.

Another and, in some cases, a better method of dealing with these tumours is to bisect the uterus downwards until the capsule of the tumour is opened. The tumour is enucleated, and the halves of the uterus are removed separately.

Hysterectomy for broad-ligament myomas.—After clamping and dividing the broad ligament with its contained ovarian vessels and round ligament, which are stretched over the tumour, the latter is enucleated as far as it will easily separate. The opposite broad ligament is divided in the classical manner, and the uterine artery on that side having been secured, the body of the uterus is amputated towards the tumour, the uterine vessels on that side being clamped as they come into view or spurt. The enucleation of the tumour from its bed in the base of the broad ligament is now easily effected, and the whole mass removed. The difficulty in these cases arises from the danger of hæmorrhage from the uterine vessels on the tumour side.

During the removal of either a cervical or a broad-ligament myoma the greatest care must be taken to avoid injuring the ureters; this is best done by working inside the capsule of the tumour in the manner just described.

Irradiation treatment.—Of recent years irradiation, chiefly by means of X-rays, has been used in the treatment of fibroids. Though, by experimentally subjecting removed fibroid tumours to strong irradiation, changes in the tissue have been produced, yet in practice probably the entire effect produced is, in my opinion, due to the action of the rays on the ovaries. The essential cells of these organs are destroyed, and the organs themselves undergo atrophy, so that on inspection when a subsequent abdominal operation becomes necessary they resemble those of a woman past the climacteric; in fact, a premature climacteric is produced, with the same results that used to follow double oöphorectomy in the days when hysterectomy was an operation too dangerous to be ordinarily performed. In a certain proportion of the cases the menses cease altogether and the tumour atrophies more or less quickly. In many other cases no effect on the bleeding is obtained, or, though obtained, there is continued growth of the tumour.

To the author's mind the whole of this treatment is retrograde, being in essence a bloodless method of spaying the patient, thus sacrificing healthy organs of great value in the economy for one (the uterus) that is diseased and useless.

There are a few cases of women at the climacteric, on whom for some

reason an operation is contra-indicated, in which treatment by irradiation may be properly advised; but to produce an artificial climacteric on the chance of relieving the menorrhagia and the much smaller chance of causing disappearance of the tumour is, I think, to be condemned. I have already seen violent menopausal symptoms resulting from thus abruptly destroying the essential ovarian tissue, and after irradiation have had to operate and remove the tumour on account of continued growth, continued bleeding, or acute septic degeneration. If the operation for the removal of the tumour were accompanied by a considerable risk, as in the old days, irradiation would have a better justification than double oöphorectomy had then; but now, when the mortality of myomectomy and hysterectomy for fibroids in expert hands is, taking all cases, barely over 1 per cent., a bloodless method of spaying has come too late.

ADENO-MYOMA

These tumours, the "unencapsuled fibroids" of the older writers have only recently been generally recognized. Macroscopically they form a mass in the uterine wall underneath the mucous membrane, and blending with it; this may be limited to one part, or may extend right round the cavity. The cut surface has a peculiar honeycombed appearance, shown by the microscope to be due to areas of tissue, exactly resembling the structure of the endometrium, embedded amongst the interlacing muscle bundles which make up the rest of the tumour. The etiology is unknown. The age-incidence and symptoms are indistinguishable from those of myomas. The treatment is that for myomas, from which they can only be diagnosed after removal of the uterus. They cannot be enucleated.

Growths similar in structure but generally malignant in behaviour occasionally occur in the recto-vaginal septum.

SARCOMA

Sarcoma of the uterus is usually met with as a degenerative complication of uterine myomas, but it may occur apart from those tumours. Histologically it may belong to the round-, spindle-, or mixed-celled types, while myo-sarcoma, endothelioma, and giant-celled sarcoma are occasionally encountered.

Symptoms.—A sarcoma may appear as a rapidly growing intra-uterine polyp, which soon recurs after removal; at other times it forms a large nodular tumour resembling a myoma, but differing from it in its rapidity of growth, its fixity, and the presence of peritoneal fluid. In either case uterine hæmorrhage is likely to be pronounced.

Diagnosis.—The malignant nature of polypoid sarcoma has often been overlooked from failure to investigate microscopically the

tissue removed. When a large mass can be felt from the abdomen a diagnosis of myoma may be made and operative treatment postponed under this error. The rapidity of growth and the signs of ascites should awaken suspicion.

Sarcoma of the cervix is very rare. A peculiar form is occasionally seen in young children, in which the surface of the mass is studded with numerous elevations (grape-like sarcoma). In adults it most commonly assumes a polypoid form. The symptoms are those of hæmorrhage and pain, and the only possible treatment is wide removal, preferably by Wertheim's method (*see* p. 44).

UTERINE POLYPS

Symptoms.—Four varieties of uterine polyps are found.

1. *Adenomatous and cystic polyps.*—The structure of the growth is similar to that of those occurring in the cervix (*see* p. 37), except that the glands are tubular, not racemose (Fig. 611). The early symptom is menorrhagia and irregular loss, which later, as the growth extrudes, becomes continuous.



Fig. 611.—Adenomatous mucous polyp, the inflammatory stroma containing elongated hypertrophic glands.

2. *Myomatous polyps.*—The symptoms are those of a submucous myoma, as described at p. 58. The loss is more strictly periodic than that associated with mucous polyps, the tumour having little vascularity.

3. *Placental polyps.*—Occasionally a portion of the gestation products after abortion or labour remains adherent to the uterine wall and becomes partially organized. Such pedunculated masses occasion more or less continuous loss, dating from the termination of the pregnancy.

4. *Malignant polyps.*—Sarcoma is the only form of malignant growth that commonly becomes actually polypoid. The symptoms of these growths have been dealt with above.

Diagnosis.—So long as the polyp is contained entirely within the corpus, its presence can only be discovered after dilating the cervix. It may be suspected, however, when with bleeding and some uterine enlargement the cervical canal is found unnaturally patent.

Treatment.—The cervix having been dilated, the polyp should be removed by torsion and evulsion, except in the case of large myomatous tumours (*see* p. 61). After the removal of an adenomatous or cystic polyp the mucosa should be curetted. If the polyp be found to be malignant, total extirpation of the uterus and adnexa must be performed.

THE FALLOPIAN TUBE

SALPINGITIS

Pathology.—In the vast proportion of cases the route of tubal infection is through the uterus. Thus salpingitis follows on endometritis of puerperal, postabortional, gonorrhœal, or postoperative origin. Occasionally, however, it is met with in virgins in whom none of these causes are in operation, and in such cases it is either due to the upward extension of a simple cervicitis (*see* p 27), or is primary in the tube itself. These primary forms are almost always tuberculous.

Rarely the tube may be infected through the abdominal ostium from an appendicular abscess or a tuberculous peritonitis.

Acute salpingitis may be suppurative or non-suppurative.

1. *Acute suppurative salpingitis.*—The tube is swollen and red; the peritoneum covering it and the adjacent parts is injected, and soft adhesions unite it to the omentum and to neighbouring coils of gut. The tube wall and plicæ are infiltrated with polymorphonuclear leucocytes, and the lining epithelium is largely destroyed, while the lumen contains pus. The mesosalpinx is thickened by diffuse lymphangitis, the ovary is adherent and may contain thin-walled cysts due to acute serous exudation into the follicles, whilst the peritoneum in the neighbourhood is often raised in irregular blebs by serous exudate. In the most acute cases there is a direct outpouring of pus through the abdominal ostium into the peritoneal cavity. More commonly, however, the tubal fimbriæ, by swelling and adhesion, rapidly occlude the opening, the pus collects in the tube, and thus a *pyosalpinx* is formed. (Fig. 612.)

On account of the fixity of its mesosalpingeal border a distended Fallopian tube assumes a curved shape, curling downwards and inwards. Thus the tube usually almost encircles the ovary, and, as a rule, its lower end is adherent to the floor of the recto-uterine pouch.

Acute salpingitis is commonly bilateral. The subsequent fate of a pyosalpinx varies. It may spontaneously discharge into the rectum,

to which it has previously become adherent; more rarely it may empty itself into the vagina, bladder, or uterus; exceptionally its wall may give way and the pus escape into the peritoneal cavity. More often it becomes surrounded by a mass of adhesions to the uterus, the broad ligament, the bowel, and the omentum, and thus becomes sequestered (*see* Chronic Salpingitis).

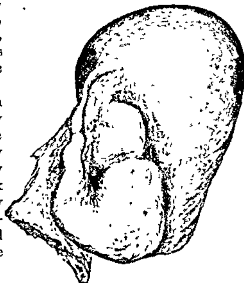


Fig. 612.—Uterus with pyosalpinx attached. The ovary is fairly healthy.

Tubo-ovarian abscess.—An acute pyosalpinx is frequently complicated by one or more follicular abscesses of the ovary on the same side Occasionally the cavity of the pyosalpinx communicates with the cavity of the ovarian abscess, a retort-shaped swelling being formed which tends to burrow in the broad ligament. (Fig 613.)

2. *Acute non-suppurative salpingitis.*—In less severe infections, suppuration may not occur. In such cases the tube, if distended, contains a serous fluid, often turbid and discoloured (*acute hydrosalpinx*). Occasionally, considerable hæmorrhage occurs into the tube lumen. The result is a hydro-hæmatosalpinx (*acute hæmorrhagic salpingitis*). In other respects the anatomy of the diseased tube is the same in non-suppurative as in suppurative salpingitis; but so long as suppuration has not occurred, spontaneous resolution is possible.

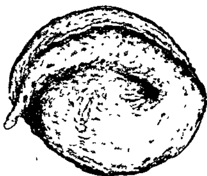


Fig. 613.—Tubo-ovarian abscess.

Chronic salpingitis.—Chronic salpingitis is usually the sequel of the acute variety, but occasionally cases are met with in which no history of the latter is forthcoming. Some of these are due to tuberculous disease.

Three conditions may be encountered—(1) chronic pyosalpinx, (2) chronic hydrosalpinx, (3) chronic fibrotic salpingitis.

1. *Chronic pyosalpinx.*—An old pyosalpinx which has become densely adherent to the adjacent parts, together with the thickened

the inflammatory changes are most marked in the substance of the tube wall, and there is comparatively little exudation into its lumen. The tubal plicæ become much hypertrophied, and the epithelium covering them tends to dip downwards, forming many crypts, and therefore presenting an adenomatous appearance under the microscope (Fig. 615). The wall becomes greatly thickened, at first by cell proliferation and œdema, and later by fibrosis. The tube curls downwards and becomes densely adherent to the ovary, the back of the broad ligament, the uterus, the intestine, especially the pelvic colon, and the omentum. The ovary is often cystic as well. The result is a conglomerate mass lying to one side of the back of the uterus, and commonly referred to as a "diseased appendage."

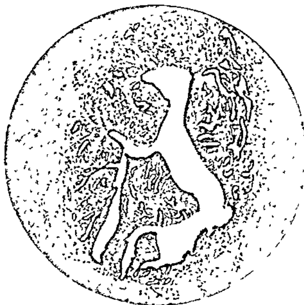


Fig. 615.—Sclerotic salpingitis.

The plicæ are swollen and distorted, and the subepithelial tissues crowded with inflammatory cells. The epithelium has proliferated, forming many gland-like spaces.

Clinical features. Acute salpingitis. *Symptoms.*—The symptoms of acute salpingitis are those of pelvic peritonitis. The onset is sudden, with severe pain referred to the lower abdomen, the temperature and pulse-rate are high, and there may be some sickness. The bowels are constipated, or when opened occasion much pain. Micturition may also be painful.

Physical signs.—From the outset there are tenderness and rigidity over the lower abdomen, perhaps more marked on one side. After a day or two an indefinite swelling rises above the pubis. This swelling may be mesial in position, or more marked to one side of the middle line. Resonance is only partially impaired over it, because it is largely made up of adherent coils of gut. At the end of a week it may have attained the level of the umbilicus, and have become much more defined and dull. On vaginal examination nothing but great tenderness to one or both sides of the uterus is first noticed, but later a definite

swelling or swellings can be distinguished, extending from the sides of the uterus into the pouch of Douglas. Eventually, in bilateral disease, a large, very tender mass is felt behind and to the sides of the uterus, which it tends to push forwards. The mass is continuous with that felt from the abdomen, and always lies in front of the rectum, which it may compress against the sacrum.

Clinical course.—This varies. In favourable cases the symptoms begin to subside in about three days, and after a period of some week or two complete recovery may ensue. More commonly, however, subsidence is only partial, a permanently tender fixed swelling being left in the region of the appendage, accompanied by the symptoms of chronic hydrosalpinx or fibrotic salpingitis.

In the more severe cases (*acute pyosalpinx*) the temperature continues to rise after the fourth day, and becomes very remittent, indicating the formation of pus in the tube. Rigors may occur. Three courses are now possible. In the first, after some days, a discharge of pus from the rectum may indicate spontaneous evacuation of the retained pus. The symptoms may greatly ameliorate after this event, but since both tubes are usually affected and these spontaneous openings do not drain well, the symptoms after initial improvement frequently recur. In the second course no spontaneous discharge occurs, but the patient gradually passes into a state of chronic fever and pain with recurring exacerbations (*chronic pyosalpinx*).

Finally, in the worst cases, namely, those in which pus escapes through the abdominal ostium into the peritoneal cavity, the symptoms of generalized peritonitis may be present. Except in this event, and the still rarer one of spontaneous rupture of the distended tube into the peritoneal cavity, it is uncommon to find pus actually in the peritoneum in cases of salpingitis.

Chronic salpingitis. *Symptoms.*—The symptoms of chronic salpingitis vary with the condition of the diseased tube.

Where a pyosalpinx is present, the leading feature is continual pain and tenderness over the affected tube or tubes, with recurring exacerbations accompanied by fever and sickness. These exacerbations are often synchronous with the menses and are provoked by exertion or intercourse, and coitus is usually unbearable. Intermittent discharges of pus from the tube, via the uterus, may take place. The menses are excessive, prolonged, and often anticipated.

In hydrosalpinx and in fibrotic salpingitis these exacerbations are not so marked, but pain is continual in the lower abdomen on one or both sides. Dysmenorrhœa, dyspareunia, and sterility are present.

All forms of salpingitis are almost constantly accompanied by endometritis and cervicitis, the symptoms of which are also present.

The uterus is often retroverted, especially in salpingitis of post-parturitional origin.

Diagnosis. Acute salpingitis.—The symptoms of ruptured tubal gestation, of axial rotation of an ovarian tumour or a pedunculated myoma, of appendicitis, of diverticulitis, of a suppurating ovarian cyst, and of acute pelvic cellulitis, all more or less resemble those of acute salpingitis.

The physical signs of *ruptured tubal gestation* are almost identical with those of salpingitis, but there is less abdominal tenderness, the pain is markedly unilateral, the patient looks exsanguined, and the temperature at the beginning is either not raised or is actually subnormal. A history of previous amenorrhœa is in favour of tubal gestation, for though the period may be suppressed in acute salpingitis, and particularly in tubo-ovarian abscess, this occurrence *follows* the onset of the symptoms. Bleeding from the uterus generally accompanies the symptoms of ruptured extra-uterine gestation.

Axial rotation of a tumour is distinguished by the presence of a well-defined tumour, often fluctuant and always dull on percussion in the earliest stages of the attack. The mass formed by acute salpingitis is never definite for at least a week, rarely fluctuates, and commonly is partially resonant.

[illegible]

simulated. Sickness, distension, and constipation are greater with appendicitis than with salpingitis. Further, a patient with appendicitis is more ill than one with salpingitis exhibiting the same degree of physical signs If a definite mass can be felt per vaginam in the position of the right uterine appendage, the case is probably one of salpingitis.

Diverticulitis affecting the pelvic colon (its most common site) may be impossible to distinguish from salpingitis unless the appendage itself can be palpated distinct from the swelling.

When an *ovarian cyst* in the pelvis suppurates, the signs and symptoms of salpingitis are simulated. Here again the mass is from the beginning well defined, and is, moreover, entirely central in position.

Pelvic cellulitis resembles acute salpingitis in its abrupt onset with fever and pain. The symptoms are less severe, however, and at first there may be little to make out per abdomen; later, when a swelling appears there it is noticeably lateral, and extends outwards towards the iliac fossa. On vaginal examination a typical lateral cellulitis (the only form that could be confounded with salpingitis) stretches outwards from the uterus to the side wall of the pelvis. The induration arches downwards, comes into relation with the lateral vaginal wall, and is not felt through the posterior fornix. It is to be remembered,

however, that more or less cellulitis of the upper part of the broad ligament usually accompanies salpingitis.

Chronic salpingitis.—The mass formed by chronic salpingitis, especially an old pyosalpinx, may be so solid and large as to simulate an ovarian tumour, or a myoma attached to the side of the uterus. From these it is distinguished by its tenderness, and by the history and symptoms of inflammation.

A diseased appendage lying behind a retroverted uterus may be mistaken for the retroflexed fundus; it can be differentiated by careful bimanual examination and the passage of a sound under an anæsthetic.

Tubal carcinoma forms a mass impossible to diagnose from chronic salpingitis except by operation.

In chronic cellulitis and encysted broad-ligament abscess the mass is strictly unilateral, displaces the uterus to the opposite side, and does not extend behind it.

The diagnosis of the *exact condition* of a chronically inflamed tube is important. A *pyosalpinx* may be suspected if recurring attacks of fever are a feature of the case, or if the mass is very large and tender. A *hydrosalpinx* may be felt as a fluctuating elongated swelling, and is much less tender than a pyosalpinx. *Fibrotic salpingitis* is distinguished by the smaller size of the mass, its fixity and hardness, and by the fact that the symptoms are those of chronic pelvic pain without exacerbations. A *tuberculous* origin is to be suspected where, in a virgin, a considerable mass is found, unexplained by the history.

In conclusion, the frequency of diagnostic error in these cases, even by the most expert, must be strongly emphasized; the surgeon's primary duty is to determine the correct treatment, rather than the actual anatomical nature of the swelling felt.

Prognosis.—A patient rarely dies of salpingitis. In acute cases that rapidly subside without the formation of pus the tube may possibly return to the normal, although in most cases the abdominal ostia probably remain permanently sealed up, and so produce sterility.

If pus has formed, the tube is permanently disorganized. In chronic cases all hope of restitution to the normal must be abandoned. The longer the duration, the greater the likelihood of secondary disorganization of the ovary by adhesion, peripheral sclerosis, and follicular-cyst formation.

Treatment. Acute salpingitis.—It used to be advised that, whenever possible, operative measures should be postponed until the acute stage had passed, (1) because if no pus forms the condition may entirely subside, and (2) because it was alleged that an operation during the height of the attack is much more difficult and dangerous, since the tubal contents are virulent, the tissues are so soft and vascular that ligatures cut through them, the bowel wall is friable

and easily tears, and the patient's general condition is unsatisfactory. Increasing experience has, however, convinced me that cases of acute salpingitis should be operated on with the same promptitude as cases of appendicitis—that is to say, within a few hours or days from the beginning of the symptoms.

1. The earlier the operation is undertaken the easier it will be. If performed within the first twenty-four hours the tubes will be found merely red and swollen, and quite freely movable, and such adhesions as have already formed are separated with the greatest ease. To bring up and remove such tubes is the simplest of surgical procedures. With every day of delay, however, the parts get more fixed and infiltrated, the adhesions more profound, and the inflammatory induration and swelling more extensive and difficult to deal with, until at the end of a week all those difficulties and dangers have materialized which caused the older gynæcologists to shrink from the operation unless absolutely compelled to do it. By waiting the surgeon deliberately courts these difficulties and dangers, whereas by operating at once he entirely avoids them.

2. By early operation it is nearly always possible to remove the tube or tubes alone, because at that phase the infection is limited to them. In cases in which operation has been delayed the ovaries quite commonly are well involved in the infective processes, and so disorganized that their removal with the tubes cannot be avoided.

It used to be argued that by waiting a number of the cases would spontaneously get well. It is true that many will, but in the vast proportion of them the affected tube or tubes remain permanently closed and functionless.

3. Early operation avoids the risk of disaster due to a possible mistake in diagnosis. Certainty that any given case of pelvic peritonitis is due to salpingitis is frequently impossible, for appendicitis, diverticulitis, and ruptured tubal gestation, besides rarer conditions, simulate it closely, and postponement of operation in any of these may be disastrous.

4. In cases in which an operation has been long postponed the pus in the tube has very likely already begun to discharge into the bowel (the natural cure in cases entirely left alone), or is on the point of doing so. The result is that the surgeon, on removing the tube, either finds a hole already in the bowel, or a spot so thinned that it gives way within twenty-four hours of the operation. In either case a fæcal fistula results.

As regards the nature of the operation, when the tube alone is affected *salpingectomy* is generally the operation of choice. It consists in dissecting the tube off the mesosalpinx and dividing it at the uterine cornu; or if it be desired to remove the entire structure, a

wedge-shaped portion of the cornu containing its interstitial segment is excised and the gap closed by sutures.

If it is especially desirable not to remove the tubes, they may in some cases be left *in situ* and the pelvis drained, but the surgeon takes the risk of having subsequently to reoperate.

In some cases the ovary is disorganized, contains collections of pus, or is conjoined to the tube in a tubo-ovarian abscess; then the removal of the whole appendage is required (*salpingo-oöphorectomy*). The tube and ovary having been separated from the surrounding adhesions, the ovario-pelvic ligament is clamped and divided, and, the inner attachments of the appendage being ligatured in halves, the tube and ovary are removed. The ovario-pelvic ligament is then ligatured and all oozing stopped.

Where acute metritis coexists with an acute double pyosalpinx it is sometimes advisable to remove the whole uterus as well, especially if both ovaries have had to be excised, for the uterus is useless after the removal of both appendages, and if conserved may be the source of discharge and pain.

After all operations for acute salpingitis, it is advisable to drain the pelvis.

Chronic salpingitis.—The treatment of chronic salpingitis varies with the presumed condition of the tube. A pyosalpinx must, of course, be removed; and the same course must be adopted for any considerable inflammatory enlargement of the appendage, whether the presence of pus be diagnosed or not. A hydrosalpinx should be similarly treated. Fibrotic salpingitis of old standing, and forming but a little mass, need not be interfered with unless it gives rise to sufficient pain and disability to justify the operation.

The ideal operation for chronic salpingitis is *salpingostomy*, which consists in freeing the tube from its adhesions, fashioning a new abdominal ostium by slitting, evacuating the contents, and stitching back the edges of the opening so as to evert the mucous membrane. Unfortunately, this can only be done with chances of success in those cases in which the uterine ostium is patent. In these it will be observed that the tube is *not* distended. Marked distension implies that *both* ostia are closed, and in such cases, if an attempt is to be made to restore capability of impregnation, it will be necessary to graft the isthmic end of the tube into the uterus.

In all cases of pyosalpinx, and in others where the conservation of the tube is either impossible or, on account of the patient's age, useless, salpingectomy or salpingo-oöphorectomy must be performed. The former should always be preferred if the ovary be reasonably healthy.

In some cases of double pyosalpinx with extensive dense matting of the pelvic organs, removal of the tubes is facilitated by performing

subtotal hysterectomy as well. Lastly, where both appendages are so diseased as to require removal, and the uterus is the seat of chronic inflammatory changes, producing menorrhagia and continual discharge, total hysterectomy should, in addition, be carried out.

TUBAL GESTATION

Etiology.—The cause of tubal gestation is unknown. Investigation of early cases shows the tube to be normal except at the site of the pregnancy.

Repeated tubal pregnancy occurs so frequently as to indicate some peculiarity in certain subjects inclining them to this disaster. The event most commonly occurs either in a first pregnancy or after some years of sterility.

The suggestions of etiological relationship to salpingitis, to tubal stenosis or diverticula, or to the passage of the ovum from the ovary of the opposite side are not supported by research.

Pathology.—The oösperm burrows through the tubal epithelium and embeds itself in the muscular wall by means of its trophoblast. It develops there in a cavity known as the *gestation sac*, formed in the maternal tissues by the destructive action of the trophoblastic cells. The small track into the tube wall is early occluded by fibrinous deposit, so that the gestation is at first entirely intramural in position. (Fig. 616.)

Primary rupture of the gestation sac.—The continued growth of the ovum leads to rupture of the gestation sac usually within eight weeks of the beginning of gestation. Rupture is brought about (1) by the erosion of the trophoblast and (2) by extravasation of blood into the gestation sac when some large maternal vessel is opened up by the invading trophoblastic cells.

Primary rupture of the gestation sac may occur in one of five directions.

1. *Intraperitoneal rupture.*—The sac perforates through the serous covering of the tube into the peritoneal cavity. This disaster, usually seen in isthmic gestation, because of the small size of the tube there, produces the most severe symptoms. Bleeding is profuse, and may cause death in two or three hours. This is the more striking because the gestation is often less than a month old, the patient bleeding to death from a tubal enlargement not bigger than a marble. (Fig. 617.)

2. *Intraligamentous rupture.*—Occasionally the sac perforates between the layers of the mesosalpinx. A broad-ligament hæmatoma results, and may attain a large size, but the bleeding is much less rapid than in the preceding variety and the symptoms are proportionately less severe.

3. *Intratubal rupture* (*tubal abortion*).—In ampullary gestation the sac commonly ruptures into the tube lumen. The blood flows into the tube and, escaping through the abdominal ostium, drips into the pelvis, and by its accumulation forms a *hæmatocele*. If the ostium is already closed or becomes blocked by clot the tube is distended



Fig. 616.—Transverse section of a ruptured three-weeks' tubal pregnancy. The gestation sac is entirely intramural. The lumen of the tube is somewhat dilated.

A, Mesosalpinx; B, gestation sac; C, fibrin mass; D, site of rupture; E, wall of gestation sac infiltrated by fœtal cells

and a *hæmatosalpinx* is formed; its contents often leak through the uterine ostium, causing continuous or intermittent vaginal loss.

Occasionally the "blood drip" from the abdominal ostium may become encysted around this orifice (*peritubal hæmatocele*).

4. *Intramural rupture* (*tubal mole*).—This form of primary rupture

of the gestation sac is due to its sudden distension by extravasated blood. The sac wall gives way and the blood burrows along the musculature of the tube, forming an intramural hæmatoma, in the midst of which lies the ovum, usually completely separated from its attachment to the maternal tissues. The blood clots, and a "tubal blood-mole" is formed (Fig. 618).

This may remain sequestered in the tube wall and possibly eventually become absorbed; more often, however, the sac gives way in a new direction owing to the fact that the trophoblastic cells in the infiltration zone remain active after the fœtal rudiment has perished. This secondary rupture may be intraperitoneal or intratubal. In either case the blood-mole becomes extruded, and is found either loose in the peritoneal cavity or in process of extrusion from the tube lumen.

5. *Intra-uterine rupture.*—This can only happen in gestation in the interstitial segment of the tube, and is a rare event. It would produce the signs of miscarriage with severe bleeding, and its occurrence is probably usually overlooked.



Fig. 617.—Acute intraperitoneal rupture of an early tubal gestation (half actual size).



Fig. 618.—Tubal mole in section.

Secondary ruptures.—In most cases of tubal gestation there have been several ruptures of the gestation sac and tube before operation. Thus, after primary intramural rupture, secondary rupture of the sac into the tube lumen or peritoneum may occur. In other cases the hæmatosalpinx formed by primary intratubal rupture may subsequently give way. This fact accounts for the usual history of several attacks of pain and faintness at intervals of some hours or days. Many of these secondary ruptures produce quite temporary escapes of blood through the apertures being quickly closed by blood clot.

Secondary sacs (*intraperitoneal and intraligamentous gestation*).—Rupture of the primary gestation sac, which always occurs before the third month, usually kills the embryo, but occasionally, if the chorionic villi retain their attachment to the tube wall, the gestation survives and continues to grow in a secondary sac either in the peritoneal cavity or between the layers of the broad ligament. (Fig. 619.) In the first case the sac wall is formed by the tube, the back of the broad

in the remainder it is passed as small shreds that escape notice in the general loss.

Symptoms and signs.—Until the gestation sac ruptures, the symptoms of tubal pregnancy are indistinguishable from those of intra-uterine pregnancy. Amenorrhœa and morning sickness are present, and in due course the breasts enlarge.

The symptoms and signs produced by the rupture of the gestation sac are very varied, and can only be interpreted in the light of a full understanding of the pathology of the condition.

1. Acute intraperitoneal rupture.—When the primary gestation sac ruptures acutely into the peritoneal cavity the symptoms are most fulminant. The patient is suddenly seized with severe pain and faintness, and soon presents all the symptoms of urgent internal hæmorrhage. The skin is blanched and cold, the pulse very fast and small, the respirations are gasping, the mental state is one of acute anxiety. The pain is referred to the abdomen generally. On examination, localizing signs may be slight or absent altogether, for the tubal enlargement is small and liquid blood in the peritoneum produces no tangible tumour, though after a while abdominal rigidity and slight distension may be noticed. These cases may end fatally in a few hours.

2. Intramural and intratubal rupture.—Intramural rupture produces an attack of acute pain due to the rapid swelling of the tubal tissues. If the gestation is destroyed by this event, no further symptoms may occur, and all that can be found is a slight enlargement in the continuity of the tube. More commonly, however, there follows a secondary rupture into the lumen of the tube or into the peritoneum, in which case the attack of pain is repeated, with more severity. Faintness and the symptoms of internal hæmorrhage are present, and the signs of a pelvic hæmatocele develop.

Intratubal rupture may, however, be the primary event, in which case the first attack of pain is more violent and faintness more constant. The signs depend upon whether the abdominal ostium is patent or not. In the first case the blood finds its way into the pelvis and, gradually mounting, floats up the intestines and omentum. Blood in the peritoneum acts as an irritant to that membrane, and it has been shown that its presence there is followed in a short time by the appearance of micro-organisms. A plastic peritonitis is thus set up, matting the intestines and omentum around the collection of blood, now known as a *hæmatocele*. In the second event all the blood collects in the tube lumen, and a large *hæmatosalpinx* is produced. In most cases the double condition obtains, i.e. part of the blood is poured into the pelvis and part is retained in the tube.

Intratubal rupture (tubal abortion), either primary, or secondary to intramural rupture, is the commonest termination of tubal pregnancy,

and its symptoms—namely, recurring attacks of abdominal pain and faintness, associated with bleeding from the uterus and the formation of a pelvic mass—are those classically associated with extra-uterine gestation. The recurring pain is produced by the successive ruptures of the tube wall with each fresh outburst of bleeding, while the uterine hæmorrhage is chiefly due to the leakage of the hæmatosalpinx through the uterine ostium, though part of it may be caused by the separation of the intra-uterine decidua.

The mass felt is a conglomerate consisting of the swollen tube, peritoneal lymph and adhesions, the matted intestine and omentum, and the blood free in the pelvis. It appears after the lapse of some days, and becomes increasingly defined and hard as the blood clots.

Where a hæmatocele is formed, the mass lies directly in front of the rectum, and the uterus is pressed forwards on to the bladder, but if a hæmatosalpinx alone is present the swelling is more to one side. Fever is often present after the first day or two, owing to the resultant peritonitis.

3. **Intraligamentous rupture.**—*Rupture of the primary* gestation sac into the broad ligament is announced by severe pain referred to the lower abdomen on that side, and in a short time an indefinite swelling in the region of the broad ligament is felt. This swelling becomes more defined and enlarged, every increment in size produced by fresh bleeding being accompanied by exacerbation of the pain.

A very large tumour may thus be formed, displacing the uterus to the opposite side, and mounting up into the abdomen behind the peritoneum to one side of the middle line.

4. **Intraperitoneal and intraligamentous pregnancy.**—A living gestation in the peritoneal cavity or between the layers of the broad ligament forms an elastic fluctuating tumour lying either behind the uterus (intraperitoneal) or to one side of it (intraligamentous). Definite uterine enlargement is present, and the signs of fœtal life and active placental circulation may be detected over the tumour.

There is usually a history of an attack of pain in an earlier period of the pregnancy corresponding to the rupture of the primary gestation sac. The severity of the symptoms varies: some patients suffer no more discomfort than is common in the later months of normal pregnancy; others have persistent pain or interference with the intestines amounting to partial obstruction.

Secondary sacs sometimes rupture, the fœtus escaping among the intestines; or the extra-uterine placenta may accidentally separate and cause internal hæmorrhage.

5. **Sequestered extra-uterine pregnancy.**—Where sequestra-

tion has not long occurred the history of an apparent pregnancy terminating in spurious labour will at once indicate the nature of the mass felt. After many years, however, the history may be indefinite, and diagnosis then is difficult or impossible. Most of these cases present themselves because of suppuration round the sac, and in some the extrusion of fœtal bones through the sinuses formed will elucidate the nature of the condition. In others it can only be decided by operation.

Diagnosis.—Acute intraperitoneal rupture of the primary gestation sac may be mistaken for perforation of a gastric or intestinal ulcer, fulminant appendicitis, volvulus and other forms of acute intestinal obstruction, rupture of a solitary ovarian abscess or ovarian blood-cyst, or acute torsion of an ovarian or uterine tumour. In all these catastrophes the striking feature is the suddenness of onset of the symptoms. The two chief points that distinguish acute tubal rupture are the history of preceding amenorrhœa and the signs of internal hæmorrhage, as compared with the signs of shock which characterize most of the other disasters mentioned.

Rupture of an ovarian blood-cyst or severe hæmorrhage from dehiscence of a Graafian follicle produces symptoms indistinguishable from acute rupture of a tubal gestation, but the history of amenorrhœa is wanting. Torsion of an ovarian cyst may cause profuse intracystic bleeding, but the presence of a tumour from the outset distinguishes it from the ruptured gestation, in which a mass is only formed after a day or two.

The symptoms of intratubal rupture (tubal abortion), which are often preceded by those of intramural rupture (the formation of a tubal mole), are more likely to be mistaken for salpingitis and pelvic peritonitis, for inflammation or subacute torsion of an ovarian cyst, for subacute appendicitis, or for abortion of an intra-uterine gestation. The recurring attacks of acute pain often associated with a bloody uterine discharge, and sometimes with the passage of a cast, are classically associated with tubal gestation.

The history of preceding amenorrhœa is an important diagnostic feature, for though suppression of a period may occur with acute salpingitis, and particularly with tubo-ovarian abscess, this *follows* the onset of the symptoms.

The mass formed by a hæmatosalpinx and hæmatocele is a conglomerate like that of acute salpingitis—substituting blood for pus—and in neither of them does it appear at once. That of tubal gestation is, however, less tender, and fever, if present, is a late development, whereas in salpingitis it is one of the earliest signs. The patient undergoing a tubal abortion is more or less pallid, and gives a history of fainting attacks with the spasms of pain, while the size of the mass

felt is disproportionate to the slight inflammatory signs. In salpingitis the patient is flushed, the pain is and has been continuous, and fainting has not occurred.

A twisted ovarian cyst presents as a tumour *from the first*, peculiarly defined and fluctuating, and there is no preceding amenorrhœa.

A tubal abortion is often mistaken by the patient for abortion of an intra-uterine gestation, owing to the pain, the blood loss, and (when it occurs) the passage of the decidual cast. Examination, by revealing the extra-uterine mass, should point to the nature of the case, but the diagnosis of postabortional salpingitis is sometimes wrongly made in these cases. A retroverted gravid uterus when incarcerated and attempting to abort may be mistaken for tubal gestation with a hæmatocele, and vice versa, but in the former the cervix is characteristically displaced so that the os points upwards and forwards.

Intraligamentous rupture presents general features resembling acute pelvic cellulitis, but the absence of inflammatory signs, notwithstanding the size of the tumour, with the blanching and the history of pregnancy, should distinguish it.

The diagnosis of later extra-uterine gestation is usually obvious, but the discrimination from intra-uterine pregnancy may be difficult if the secondary sac is closely fused to the side or back wall of the uterus.

Treatment.—All cases of extra-uterine gestation should be immediately operated upon. The older authorities used to prefer in the case of a hæmatocele to await a possible natural absorption. Apart from its involving an invalidism extending over two or three months, this practice has distinct risks: (1) Fresh hæmorrhage may occur, for the trophoblast continues to grow after the death of the fœtus; (2) the gestation may not be dead, but continuing its existence in a secondary sac; (3) the hæmatocele may suppurate.

Operation.—In acute ruptures the greatest expedition must be used, the patient meanwhile receiving saline venous infusion. The tube should be pulled up, clamped and removed, with or without the ovary according to the condition of the latter. The blood in the peritoneum is then rapidly cleared out, and the wound closed. In hæmatosalpinx or hæmatocele presenting less violent symptoms the technique is that of the operations for salpingitis (*see* p. 77). The ovary should always, if possible, be conserved. The opposite tube is found occluded in many cases, but salpingostomy is usually feasible. Pelvic drainage is not generally necessary after removing the blood-clot, but if definite fever has been present a small tube should be introduced through the lower end of the wound for a day or two.

If a broad-ligament hæmatoma is found, the blood should be evacuated, the involved tube removed, and the cavity in the broad

ligament obliterated by sutures, or, if too large for this procedure, brought to the surface and drained.

A ruptured interstitial gestation may be treated either by subtotal hysterectomy—or better, if possible, by exsection of the tube and cornu—and repair of the uterus by sutures.

Intraperitoneal and intraligamentous gestation should be treated by removal of the sac. In the first case the adhesions to the omentum, the back of the uterus and broad ligament, and to the bowel, will have to be dealt with. Where possible, they should be ligatured or clamped before division, but in any circumstances the bleeding will be very free.

In the second case the hæmorrhage will be still more marked, the whole of the sac being commonly placentous. It is frequently best in these circumstances to remove the body of the uterus as well as the tube on the involved side. In either event the operation requires rapid and determined execution.

In the last three months of extra-uterine pregnancy the risk of severe hæmorrhage during the operation is such that until recently authorities agreed in preferring to await, if possible, the death of the fœtus and cessation of the placental circulation, after which the removal of the gestation is comparatively easy. Recent research has shown, however, that the best results, even in these formidable cases, have been obtained by operating at once and removing the whole fœtal sac and placenta together with the child.

CARCINOMA OF THE TUBE

This is a rare disease. The growth assumes a papillary form which, distending the tube, eventually ruptures it into the peritoneal cavity. There is strong evidence that the neoplasm is the outcome of chronic salpingitis, in which, as already described, there is a strong tendency for the epithelium to proliferate. A very frequent symptom is a blood-stained watery uterine discharge, originating in the hydrosalpinx produced by the growth occluding the abdominal ostium of the tube. In many cases free fluid is present in the peritoneum. Diagnosis is difficult, salpingitis being closely simulated. A blood-stained uterine discharge with ascites is suggestive. Ablation of the diseased tube with the uterus and the rest of the adnexa is the only treatment.

OTHER NEW GROWTHS

Myomas are very rare in the tube. Adeno-myomas have been described. They consist of an admixture of muscle-fibres with epithelial tubules derived from the lining of the tube. They are of inflammatory origin. Sarcoma and hydatid cysts in this situation are also known.

THE OVARY

ABSENCE OF THE OVARY—ACCESSORY OVARY

One or both ovaries may be absent or infantile. Occasionally an accessory ovary outside the normal one may be present. The ovary may be found undescended and lying on the pelvic brim.

PROLAPSE

The ovary may be dragged down by a retroverted or prolapsed uterus. Not infrequently prolapse occurs with the uterus in normal position, the ligaments being relaxed from parturition or primary tissue debility.

Clinical features.—The principal symptom is dyspareunia owing to the tenderness of the prolapsed organ, though this varies enormously in different individuals. Probably some cases of chronic "ovarian" pain are due to this displacement.

Many ovaries clinically tender show at the operation filamentous adhesions previously unsuspected.

Diagnosis.—The normal ovary is not easily felt, because there is no solid background against which to feel it. Light palpation is necessary; much force pushes the organ in front of the finger, and defeats its end. Rectal examination is useful in these cases.

Treatment.—If the condition gives no trouble it should, of course, be let alone. When neurasthenia has been excluded, and the genuineness and ovarian origin of the symptoms have been established, it is proper to attempt relief.

In uncomplicated ovarian prolapse the ovario-uterine ligament should be shortened after the method first described by me in 1907. In the more common cases associated with retroversion, rectification of the uterine displacement and the use of a pessary may succeed. This failing, ventro-fixation (p. 25), combined with shortening of the ovarian ligaments is a proper course; or, better still, intraperitoneal ligamentopexy (p. 25) which very effectively pulls up the ovary.

INFLAMMATION (OÖPHORITIS)

Primary ovarian inflammation is rare, though it frequently arises secondarily to disease of the tube, as previously described. It is also frequently infected via the veins and lymphatics of the hilum in cases of puerperal or postabortional cellulitis. Occasionally a solitary *abscess occurs*, probably as a result of [illegible] of a recently dehisced follicle by the *B. coli communis.* [illegible] are very fulminant, no symptoms being present, as a [illegible] peritoneal rupture of the abscess initiates a violent [illegible] sym[illegible] [illegible]mbling

those of acute perforation of an abdominal viscus. They should be treated by oöphorectomy and peritoneal drainage.

In the condition known as "fibrotic oöphoritis," or "cirrhosis of the ovary," the organ is found much reduced in size, very hard, and devoid of follicles. The stroma shows a dense fibrosis. There is, however, no evidence that the change is inflammatory. It is met with most often in virgins, and is sometimes associated with a peculiarly violent form of dysmenorrhœa (*see* p. 108).

OVARIAN GESTATION

The cause of this rare event is unknown. The oösperm embeds itself in the wall of the Graafian follicle, and the gestation sac thus formed usually ruptures at an early period into the peritoneal cavity. Cases are, however, recorded in which an ovarian pregnancy endured for months, or even went to term. The symptoms when rupture occurs are identical with those of ruptured tubal pregnancy, and the treatment is similar, except that the ovary and not the tube claims the operator's attention (*see* p. 86).

NEW GROWTHS OF THE OVARY

OVARIAN CYSTS

There is no region of the body in which such an extraordinary diversity of new growths occurs as in the ovary, and their elucidation constitutes one of the most puzzling and most interesting problems in pathology.

The ovary is developed, like the testicle, from the genital ridge which lies immediately inside the mesonephric ridge.

In the mesonephric ridge lie the mesonephric tubules and the longitudinally-running Wolffian duct, with which they are connected. The genital ridge is very early covered in embryonic life with a special layer of cells known as the germinal "epithelium." These cells are not, however, epithelial nor even ectodermic or entodermic, but probably represent certain elements early differentiated from the rest of the cells of the morula for reproductive purposes. In the development of the somatic elements of the body a progressive differentiation of the cells occurs, first into ectoderm, entoderm, and mesoderm, and later into their specialized derivatives, such as epithelium, bone, muscle, and so forth. The cells of the germinal epithelium, however, unlike those of the rest of the body, claim undifferentiated descent from the primitive blastomeres into which the dividing oösperm first splits. From them develop the sexual elements of the new individual, in the following manner: Certain of the cells of the germinal epithelium ingrow into the genital ridge in a series of prolongations known as the

medullary cords. In the female these cell cords form the egg tubes of Pflüger, from which is developed a series of cell groups known as primitive follicles; from them the ovum and the cells of the tunica granulosa and discus proligerus are formed. In the male these cell cords develop into the cells lining the spermatogenic tubules; these tubules are subsequently brought into continuity with the mesonephric tubules and ducts, and therefore into communication with the Wolffian duct, which now acts as a conduit (vas deferens) for conveyance of their secretion (spermatozoa).

In the female, continuity between the mesonephric tubules and collecting ducts and the ingrowths from the germinal epithelium is not permanently established, the former remaining, together with the Wolffian duct, as the vestiges in the mesosalpinx and ovarian hilum known as the paroöphoron, Kobelt's tubules (epoöphoron), and Gartner's duct respectively. In the connective tissue between the egg tubes and primitive follicles are found isolated cells known as interstitial cells, certain of which are derived from the germinal epithelium, while the others belong to the connective-tissue framework.

The Müllerian ducts, from which is formed the female genital canal, are developed subsequently to the Wolffian ducts and outside them in the mesonephros.

In the earliest stage of their existence each communicates with the cœlom by three apertures which eventually fuse to form the abdominal ostium of the Fallopian tube. Occasionally this fails, and accessory ostia or cysts derived from them are found in adult life.

The ovary, therefore, besides being in immediate relation with several vestigial structures, is in the possession of cells derived from the germinal epithelium (ova, follicle cells, certain interstitial cells), the normal seat of undifferentiated embryonic cell seclusions. The enormous growth potentialities of these cells, as far as the ova are concerned, are apparently held in abeyance by the occurrence in them of a peculiar form of karyokinetic division (maiotic mitosis) whereby the number of chromosomes contained in each cell is reduced to one-half of those in a somatic cell.

Should this process fail to occur, the possibility of a tumour by asexual cell division of an ovum must be admitted. The other cells of the egg tubules, likewise derived from the germinal epithelium, are possibly also sometimes the seat of initiation of such teratomatous formations, while similar tumours may be derived from sequestered cells aberrant from the primitive egg tubes, or subsequent ingrowths from the germinal epithelium. Such an hypothesis best explains the frequency of teratomatous tumours in the sexual glands and the fact that the ovary, though it contains developmentally neither ectodermic nor entodermic derivatives, yet produces enormous tumours chiefly

composed of epithelium. The assumption that the egg cell, or the cells allied to it, are capable of growth and division without the stimulus of the spermatozoon does not rest on theory alone, for experimentally it is found possible to cause the egg cell of an animal so highly organized as a frog to develop into a tadpole by mere mechanical stimulation, whilst asexual or parthogenetic development of the ovum is well known to occur normally in many animals quite high in the scale, e.g. the bee.

Cysts in the ovarian region may be divided into four groups: (1) cysts of the ovary proper, (2) cysts of the ovarian hilum, (3) cysts of the broad ligament, and (4) cysts of the tube.

1. Cysts of the ovary (oöphoronic cysts).—All ovarian cysts are at first pedunculated, like the organ itself. Their walls are composed of stretched ovarian tissue, and have a characteristic pearly-white or bluish tint, according to their thickness and the character of the underlying contents.

Follicular cysts.—The simplest species are those derived by distension of the Graafian follicle in various stages of its existence. There are three varieties of follicular cyst: (*a*) the simple follicular cyst, (*b*) the follicular blood-cyst, and (*c*) the lutein cyst.

(*a*) *Simple follicular cysts.*—These may be single or multiple. In the former case the whole ovary is transformed into a pedunculated, thin-walled, whitish-blue cyst, containing a thin, straw-coloured fluid. In the smaller cysts the wall is lined inside with a short columnar epithelium, but in the larger ones this is flattened out or actually disappears. Multiple follicular-cyst formation is usually associated with chronic salpingo-oöphoritis, the peripheral sclerosis and adhesions preventing the dehiscence of the follicles.

(*b*) *Follicular blood-cysts.*—After dehiscence of the follicle, bleeding normally occurs into it, producing the "corpus hæmorrhagicum." This hæmorrhage may occasionally be excessive and result in the formation of a blood-cyst whose walls represent the stretched and thinned tissue of the ovary. These cysts are liable to rupture with severe intraperitoneal bleeding, and occasionally cases are met with in which, without any blood-cyst formation, severe intraperitoneal hæmorrhage has taken place from the ruptured follicle.

Of recent years our knowledge of ovarian blood-cysts has expanded, and facts have come to light which point to their formation not being due to simple intrafollicular bleeding. The content of these cysts is invariably a thick brown viscous fluid exactly resembling that found in the vagina in cases of hæmatocolpos (*see* p. 10), and Blair Bell has stated that it exhibits the same absence of fibrin ferment. There is reason, therefore, to believe that the process of the cyst-formation may be due to "intrafollicular menstruation"—the cyst contents being

It has been suggested that cysts of this group are derived by proliferation of certain of the cells of the sequestered aberrant remnants of the primitive egg tubes, or from subsequent ingrowths of the germinal epithelium. They may occur at any age from puberty onwards, but are commonest after 30.

Teratomatous cysts (dermoid cysts; embryomas).—The fact that the ovary is the normal seat of undifferentiated embryonic cell seclusions probably explains the extraordinary diversity of growths originating in that organ If so, many ovarian tumours not always

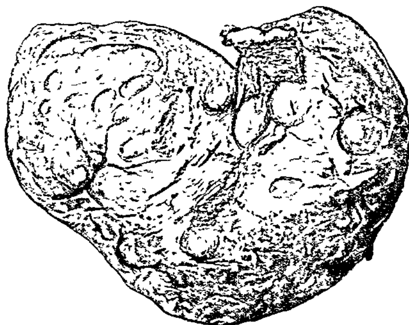


Fig. 621.—Multilocular ovarian cyst-adenoma.

considered as teratomatous might be included in this category (e g. ovarian cyst-adenomas). Setting aside these more debatable classes, there remain two whose embryonic origin is admitted by all, viz. the simple dermoid cyst and the multilocular cyst-embryoma.

Of these the *simple dermoid* is much the commoner. It is unilocular as a rule, and its wall is formed of stretched ovarian tissue (Fig. 622). At one part of it the " embryonic rudi[illegible] projection into the cavity, covered by [illegible] number of sebaceous follicles. Many [illegible] projecting from it or embedded in it may be found one or several teeth more or less well formed, and set into an irregular plate of bone (Fig. 623). Microscopical investigation of the embryonic area, besides showing a definite skin (Fig. 624), may reveal other tissues such as

cartilage, muscle-bundles, or nerves. The rest of the cyst is usually lined with a flattened or definitely cubical epithelium. It contains a yellow fat, liquid when it is first removed from the body, but rapidly hardening afterwards, and then resembling cacao butter. Embedded in it is a quantity of coarse reddish or brownish hair.

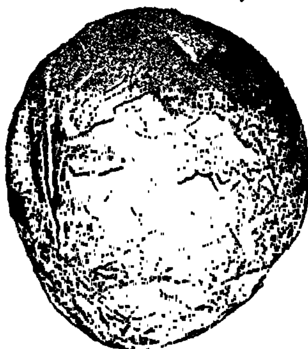


Fig. 622.—Unilocular teratomatous cyst (dermoid cyst).

The *multilocular cyst-embryoma* is much rarer. It consists in large part of solid masses intermixed with cavities of different sizes, whose contents vary from typical dermoid material to mucus and clear serum. Those containing fat are lined with a perfect skin coated with vernix caseosa like that of a new-born infant. Others present a mucous membrane exactly similar to that of normal bowel; whilst in some, columnar ciliated epithelium is found like that of the trachea. Microscopically, every variety of tissue characterizing the human body is found in irregular arrangement (Fig. 625), and in exceptional examples well-formed portions of the lower part of a fœtus may be present.

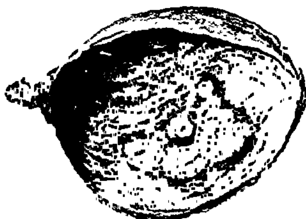


Fig. 623.—Dermoid cyst, opened to show the fœtal rudiment with two well-formed teeth.

It is a remarkable fact that endogenous teratomas, whether in the ovary or elsewhere, rarely develop before puberty, the commonest age at which they occur being between 20 and 30.

2. Cysts of the ovarian hilum (*paroöphoronic cysts*).—The cysts that occasionally develop in the hilum of the ovary are probably derived from those remnants of the mesonephric tubules known as the paroöphoron and from some of the earlier ingrowths of the germinal epithelium (rete cords). They may be unilocular or multilocular; they grow into the ovary, which lies on their posterior surface, and burrow into the broad ligament in front. They are particularly prone to develop intracystic papillomas, in virtue of which they become more or less malignant (*see* Papilliferous Cysts, p. 97) They are commonest between the ages of 30 and 50.

3. Broad-ligament cysts.—A cyst growing in the broad ligament is covered by its peritoneal layers, and as it invades the mesosalpinx has



Fig. 624.—Wall of dermoid cyst.
It shows a well-formed skin containing hair-follicles, sebaceous and sweat glands, and unstriped muscle-fibres.



Fig. 625.—Cyst-embryoma.
Various tissues are seen embedded, in which may be noted a mass of cartilage and several spaces lined with different types of epithelium.

These latter are frankly malignant, and rapidly recur after removal, but secondary nodules of the single-layered type may spontaneously disappear after the removal of the primary growth.

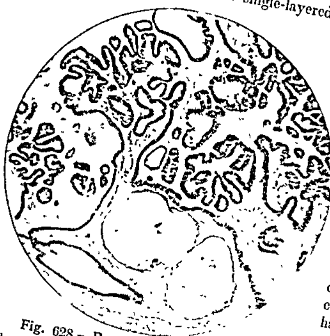
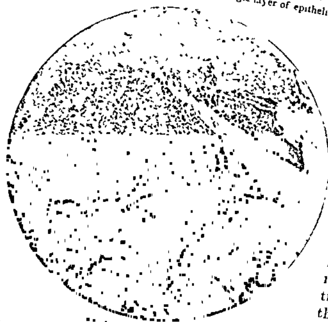


Fig. 628.—Benign papilliferous cyst.
The papillomas are covered with a single layer of epithelium

Many other forms of malignant degeneration may occur in ovarian cysts. The cystadenomas not infrequently contain solid masses having the structure of spheroidal- or columnar-celled carcinoma. Squamo celled carcinon has been recordc arising from th skin-covered surface of a dermoid cyst, whilst the cystic embryoma may become malignant in virtue of any or all of the tissues contained in it. Thus, chorion-epithelioma and various forms of carcinoma and sarcoma may all arise in it, or the whole cyst may assume malignancy, the metastases presenting the same multiform characters as the primary growth.



Malignant papilliferous cyst.
Large masses of epithelium cover the papillomatous outgrowths and infiltrate the cyst wall

A peculiar form of colloidal growth is seen in some multilocular cysts

(pseudo-myxoma ovarii). The growth perforates the cyst wall and, becoming grafted on the peritoneum, produces enormous quantities of material like painter's size, which gradually distends the peritoneal cavity. Evacuation of the contents is followed by reaccumulation, and cases are on record where this procedure has been repeated over several years. The basis of the growth is a colloid tissue containing few cells. Sarcoma of varying types may originate in a cyst wall. Secondary deposits of carcinoma in the ovary are very common, and are often partially cystic owing to the inclusion of distended follicles in the growth. They are nearly always bilateral, and are usually secondary to malignant disease of the intestine, gall-bladder, or breast.

Symptoms.—The symptoms of ovarian cysts may be divided into those due to (1) bulk, (2) pressure, (3) torsion, (4) inflammation, (5) rupture, (6) malignant degeneration.

Bulk.—The rate of growth of an ovarian cyst varies. Dermoids may grow very slowly. Cyst-adenomas attain a fair size in two years. Malignant cysts may reach a great bulk in a few months; while certain accidental occurrences such as torsion or inflammation produce very rapid increase in size.

Cysts weighing over 100 lb have not infrequently been recorded. In the absence of complications, innocent ovarian cysts do not at first affect the general health, but later the increasing enlargement of the abdomen is accompanied by the so-called "ovarian cachexia," characterized by extreme emaciation and an earthy or definitely pigmented colour of the skin.

Pressure.—Impaction in the pelvis may occur, with retention of urine, partial intestinal obstruction, and great pain; but this is a much less common event than with myomas. Enormous tumours interfere with respiration and the intestinal functions, and may produce signs due to pressure on the vena cava.

Torsion.—Torsion of the pedicle is the commonest complication of an ovarian cyst. It may follow a violent effort or the emptying of a pregnant uterus, but often no cause is apparent. The first twist is usually small, but sufficient to obstruct the venous return through the pedicle. As a result, the cyst wall and the pedicle distal to the twist become œdematous and swell. This occasions a further twisting, with increased œdema; and so on, until the blood-flow through the pedicle may be entirely arrested. The cyst becomes purple or black from venous congestion, and its contents are rapidly augmented by the effusion of serum and blood into the cavity. Occasionally large quantities of blood may be thus poured out. The necrotic wall induces peritonitis around it, with the formation of adhesions through which the circulation may be re-established. Spontaneous recovery sometimes takes place, the necrotic cyst becoming sequestered by universal

adhesions. More commonly, however, general peritonitis is set up, to which the patient would succumb if untreated.

A twisted cyst rapidly increases in size and becomes very tense and tender. It usually crosses the middle line to the opposite side, becomes markedly unilateral, and pulls the uterus in the same direction by the tension of the pedicle. The pain is at first spasmodic, the exacerbations coinciding with the successive twists; later on, as peritonitis is set up, the distress becomes continuous, and vomiting and flatulent distension appear.

Rupture.—Spontaneous rupture is most commonly seen with papilliferous cysts. The abdomen rapidly fills up with ascitic fluid, and some tenderness and pain may be present, owing to the secondary peritoneal implantations; these may be felt, on deep palpation, as irregular masses. The patient wastes, and often shows slight continuous fever.

Cyst-adenomas rarely rupture, owing to the early formation of adhesions. The escape of the mucous contents sets up a subacute *peritonitis* with pain and tenderness. Ruptured *colloidal cysts present* the same clinical picture as ruptured papilliferous cysts, but the distension and general deterioration are slower. The bursting of an *ovarian blood-cyst or profuse hæmorrhage from a corpus hæmorrhagicum* almost exactly simulates a ruptured tubal gestation, but a history of preceding amenorrhœa is absent. Thin-walled follicular *cysts may rupture spontaneously*, or in the course of examination. The fluid is non-irritant and is soon absorbed, but the cyst re-forms after a while. Very rarely the sudden effusion of blood into the cavity of a twisted cyst has caused the wall to rupture.

Malignant degeneration.—Malignant ovarian cysts give rise to a fixed mass, ascites, and rapid emaciation. Later, metastatic masses are felt in the omentum, parietes, and liver. These secondary growths, especially those in the omentum, are often the first to attract attention. They have the bossy feel of a number of rounded nodules partially fused together, and when omental may be very movable.

Diagnosis.—If the uterus cannot be separated from the mass, absolute distinction from a myoma may be impossible. Marked fluctuation and the presence of a fluid thrill are *in favour of ovarian* origin, but a cystic myoma may present the same signs. Many ovarian tumours do not fluctuate, especially dermoids and multilocular *cyst-adenomas, while cyst-embryomas and malignant* cysts are largely solid in composition. A vascular murmur over the tumour strongly suggests a uterine origin. The history of menorrhagia usual with a myoma is rare with an ovarian cyst, unless complicated by one of the former tumours.

Ovarian cysts usually grow much more quickly than myomas, while tumours first discovered under 30 or above 55 years of age are probably ovarian. The frequency with which myomas and ovarian cysts coexist must not be forgotten.

Pregnancy is distinguished from an ovarian cyst by the enlargement being uterine, by its usually greater rate of growth, by the presence over it of a vascular murmur and signs of fœtal life, and by the corresponding period of amenorrhœa.

Ovarian cysts only cause amenorrhœa when they are bilateral and have totally destroyed all normal ovarian tissue. This is chiefly seen in malignant cysts, in which the rate of enlargement may be rapid and pregnancy be more particularly simulated.

A distended bladder is immediately distinguished on passage of the catheter—a precaution never to be omitted in cases of doubt.

Ascites shows signs of movable fluid and produces a different shape of the abdomen, the loins particularly being bulged; moreover, the front of the abdomen is resonant and the flanks are dull, the reverse being the case with a cyst. Encysted peritoneal fluid, as seen in some forms of tuberculous peritonitis or in "encysted serous perimetritis," may closely simulate an ovarian cyst, but the swelling is fixed and the percussion note often partly resonant owing to adherent bowel lying over it. A large hydrosalpinx may be indistinguishable from an ovarian cyst, whilst many tense broad-ligament cysts are mistaken for broad-ligament myomas.

Retroperitoneal cysts of various kinds closely simulate ovarian cysts, but their front is resonant, and most of them (hydronephrosis, pancreatic cysts) have no connexion with the pelvis.

The diagnosis of torsion of an ovarian cyst from rupture of acute salpingitis and tubal gestation is discussed under the latter two headings (pp. 75, 85). The most striking feature of a twisted cyst is *the presence of a large cystic tumour from the very outset of the symptoms.*

A ruptured papilliferous cyst or other form of cyst with ascites may be mistaken for terminal hepatic cirrhosis or acute tuberculous peritonitis. In most cases a pelvic tumour can be felt, which excludes the hepatic condition. In tuberculous peritonitis, however, a mass may also be felt per vaginam, but in this condition there is usually much more fever than in ruptured cyst.

In all cases of doubt the peritoneal cavity should be explored. Many a woman has been tapped repeatedly for an ascites due to an unsuspected papilliferous cyst.

An inflamed cyst simulates acute pyosalpinx, but the mass is from the commencement more circumscribed and defined.

Treatment.—All ovarian cysts should be removed as soon as possible, through an abdominal incision.

A pedunculated cyst is treated by excision, the pedicle being first clamped. *Ligation of the pedicle should be carried out in sections,* to minimize the risk of the ligatures slipping. Large unilocular cysts with clear fluid contents may be tapped before removal, but all others should be excised whole for fear of escape into the peritoneum of irritant or infected matter or transplantable tumour cells. Multilocular cysts cannot be satisfactorily tapped. Adhesions to the cyst wall should be separated as far as possible before tapping if this course be followed. In the removal of some ovarian cysts it is possible for the surgeon to conserve part of the ovary—a most desirable thing. This is conspicuously so in many dermoid cysts, and also in certain ovarian blood-cysts in which only part of the ovary is involved in the cyst. Many small cysts can be shelled out of the ovary.

Sessile broad-ligament cysts are to be treated by enucleation from their peritoneal investment. This is often easy, the gap in the broad ligament being subsequently closed with sutures. In other cases only part of the cyst can be so removed; the remainder should be brought up to the abdominal wound and drained.

The excision of a broad-ligament cyst is sometimes facilitated by removal of the uterus. Where the cyst has burrowed deeply its removal may be a very difficult operation.

Ovarian cysts are sometimes universally adherent. In many instances the cyst wall can be readily shelled out, but in others this is impossible without serious damage to the intestines and mesentery. In this case the best course is to empty the cyst and then suture up the aperture, leaving the patient to be tapped subsequently as the fluid reaccumulates.

Cysts of the ovary or ovarian hilum burrowing into the broad ligament are treated by enucleation, like actual broad-ligament cysts.

Malignant cysts should be removed whenever possible; but great judgment must be exercised, for the bleeding in these cases may be so free that, once started, the operator may find it impossible to go back.

The operation of ovariotomy has nowadays a mortality greater than that of simple hysterectomy. This is on account of the large proportion of malignant cases dealt with, in which the death-rate is high. Excluding these, the average risk is probably 2 per cent.

FIBROMA

Fibrous tumours, many of them of large size, are occasionally met with in the ovary. They arise as (*a*) a diffuse fibrous overgrowth of the whole of the ovarian stroma, (*b*) a local encapsuled mass, or (*c*) a pedunculated outgrowth from the surface of the ovary. They are most frequently met with between the ages of 30 and 50. In structure they

are pure fibromas, and show much less tendency to degeneration than is the case with myomas. They take about two years to attain the size of a cricket-ball. They produce symptoms of pressure like a pedunculated subserous myoma. In most recorded cases free fluid has been present in the abdominal cavity, a circumstance that caused them in the past to be regarded as sarcomas. It is impossible to distinguish absolutely a fibroma from a subserous myoma with a long pedicle, before the abdomen is opened. The absence of menorrhagia and the detection of signs of free peritoneal fluid would suggest a fibroma. The tumour must be removed, the steps of the operation being those already described under Ovarian Cysts (p. 102).

ADENOMA

Solid adenomas in the ovary are rare. Their nature can only be ascertained by microscopical examination, when a series of regular glandular spaces lying in a fibro-cellular stroma is revealed. Like fibromas, adenomas cause some ascites and produce pressure symptoms. They must be removed as soon as possible, and if doubt as to the innocent nature of the growth exists the uterus should be removed also.

PAPILLOMA

A rare villous type of papilloma originating in the germinal epithelium, and producing secondary peritoneal growths and ascites, is known. Removal of the primary growth is followed in some cases by spontaneous disappearance of the secondary growths in the peritoneum.

SARCOMA

Many different types of primary sarcoma occur in the ovary; the endothelial and small round-cell varieties are the commonest. All ages are attacked, and cases have been recorded even in infancy. In children and young persons the growth is often bilateral, but in older patients only one side is usually affected.

Secondary sarcoma of the ovary is uncommon, except in the melanotic variety, in which large bilateral tumours may be found post mortem.

Ascites is early noticed, the tumour is fixed and grows rapidly, and the patient wastes. The diagnosis of malignancy is usually not difficult, but the occurrence of ascites with simple fibromas must be remembered. The histological nature of the growth can only be determined after removal. The uterus and both appendages must be totally extirpated.

CARCINOMA

Primary growths exhibit various characters in different cases, the tubular columnar-celled type being that most frequently met with.

remember that the excessive losses are balanced or more than balanced by periods of amenorrhœa. Constantly recurring menstrual losses are not normal to this epoch, while *continuous bleeding, contrary to the* public impression, is altogether abnormal and should be immediately investigated.

Treatment.—Functional menorrhagia is to be treated by drugs, of which the most useful are ergot, hydrastis, hamamelis, cotarnin, and calcium lactate or chloride. Where an organic cause exists operative treatment is usually advisable.

AMENORRHŒA

Amenorrhœa may be due to congenital absence or operative removal of the uterus or ovaries. Occasionally, persons structurally normal and in good health never menstruate, probably as a result of deficient ovarian activity. Congenital or postoperative occlusion of some part of the genital canal produces a spurious amenorrhœa. Amenorrhœa is particularly associated with chlorosis, while certain prolonged wasting diseases, such as tuberculosis, tend to it. Acute endometritis or oöphoritis may suppress a period, while the physiological epochs of pregnancy, lactation, and the climacteric are normally accompanied by absence of the menses.

Treatment.—The menstrual flow is not a necessity to health; its absence, therefore, requires treatment on the score of its cause alone. In chlorosis, purgatives and iron give good results. In general debility the usual tonics and hygienic régime are indicated. For functional amenorrhœa, aloes and iron are useful, and, where ovarian insufficiency is suspected, extract of corpus luteum or other of the ductless glands may be tried.

THE CARDIO-VASCULAR SYSTEM

By E. ROCK CARLING, M.B., B.S., F.R.C.S.

INJURIES OF THE HEART

Injuries of the heart of surgical interest are almost exclusively penetrating wounds. They may be accidentally or intentionally inflicted by implements or sharp weapons, by gunshot, or by impalement. Rarely the heart is punctured by a sharp body such as a needle that has gained entry at a distance; it may be damaged or its action impeded by a bullet or projectile fragment that has migrated from the vena cava. The severe lacerations of the heart produced in crushing accidents are seldom amenable to treatment. Statistics of operated cases indicate that the ventricles are injured more often than the auricles, but the right and left ventricles suffer about equally. Wounds of the right ventricle are slightly more dangerous than those of the left; the reverse is the case with the auricles.

The wound may be glancing, and divide only a few muscular fibres; or may involve a large branch of the coronary arteries; it may penetrate one or more cavities, so that there may be entrance and exit wounds, not only in the pericardium but also in the heart, together, in many instances, with simultaneous injury of the pleura, lung, diaphragm, or the abdominal viscera. In the great majority of cases in civil life the external wound is in the 4th or 5th intercostal space on the left side.

Diagnosis.—The circumstances of the accident, the situation of the superficial wound, the direction of the impact if ascertainable, and the nature of the weapon, are important considerations; in war cases the wound of entry may be at a considerable distance—in the buttock or thigh, for example. The gravity of the symptoms is not an absolute criterion of the extent of the injury, and abeyance of symptoms immediately after infliction does not eliminate the necessity for close observation if the conditions disclose the possibility of heart wound. There may be very little external bleeding; nevertheless, the symptoms and signs are referable to bleeding, and more particularly to accumulation of blood in the pericardium, perhaps

in the pleura as well; they are those, that is to say, of "heart tamponade"—for the wound in the pericardium may be valve-like, or may be plugged with clot—and of internal hæmorrhage: shock, pallor, restlessness, cyanosis and dyspnœa. The area of cardiac dullness may be greatly increased; if the pleura be wounded, as it is in 80 per cent. of punctured wounds of the heart, there may be curious auscultatory signs, such as whistlings and bubblings, and blood escaping externally may be frothy; if the weapon remains in the chest, it may exhibit movements of cardiac as well as respiratory rhythm.

Prognosis and treatment. — Although death may result instantly from a wound of the heart, yet the cardiac tissues are very tolerant of injury, and delayed death is generally due either to simple loss of blood or to compression of the heart and great vessels by accumulation of blood in the pericardium; 40 per cent. of cases submitted to operation in civil life recover. The majority of successful cases have been operated upon within six hours of the infliction of the wound; but those operated on at a later period, up to five days, have shown a higher proportion of recoveries. Presumably the injuries in these surviving cases were less severe. Statistics of war cases suggest that the recovery-rate under favourable circumstances is 60 per cent. or over.

Every case in which there is presumptive evidence of wound of the heart should be submitted to operation, unless concomitant injuries contra-indicate. Where positive-pressure anæsthesia is available it should be employed, for it diminishes the difficulties materially, but the differential pressure should not be greater than a few millimetres of mercury in the early stages of the operation, as otherwise bleeding is increased. Asepsis is of the first moment, and must receive attention even where time is of great importance and although infection of the wound itself may be presumed. The incision for exposure must be determined by the case. To obtain adequate exposure it was formerly considered necessary to resect or reflect the 3rd, 4th, 5th, and even the 6th costal cartilages, perhaps with a part of the sternum and ribs adjacent, but the tendency now is towards avoiding a flap and making use of powerful mechanical retractors to separate the ribs after division of their cartilages; especially when the incision can be planned to include the original wound and to follow the general direction of the intercostal spaces. If adequate access can be obtained without opening the pleura, so much the better; but in a majority of cases the pleura is already involved, and there should be no hesitation in opening the sac widely It is the small valve-like opening that is dangerous.

The pericardium must be emptied, the heart examined on both

aspects, bleeding vessels ligated, and the wound sutured with vaselined silk. The heart will submit to all necessary handling, and, should it stop beating, can in most cases be stimulated to activity by rhythmic compression or massage. It is convenient to put a long temporary suture through the apex to facilitate manipulation. Wounds of the pleura are to be carefully sutured after emptying the sac by siphonage, or with subsequent aspiration if necessary. If drainage can be avoided, so much the better, but usually it is necessary; the pleura and pericardium or præcordial space should be separately drained, and aspiration drainage may be advantageous. When drainage has been instituted, the most extreme care must be taken to dress aseptically, for the causes of delayed death have been pericarditis, pleuritis, peritonitis, pulmonitis (generally suppurative and of late development), and subphrenic abscess.

Of 152 cases since 1912 recorded by Ballance, 48 died and 104 recovered—a mortality of 31 6 per cent.

The heart muscle heals by fibrous tissue; the cicatrix is generally competent, but traumatic aneurysms have been recorded.

OTHER OPERATIONS ON THE HEART

Pericardiotomy.—For drainage of pus from the pericardium the exposure need not be so extensive as in the operation described above; an incision over the 5th or 6th left costal cartilage, with one in the middle line of the sternum, from the inner end of the first incision, upwards, if needed, gives ample room. In certain cases, however, it may be necessary to gain access to the left lateral aspect of the pericardium, as otherwise the sinus or cul-de-sac of Haller cannot be satisfactorily drained (Ballance). The cartilage is excised without its perichondrium, the internal mammary artery ligatured and divided, the triangularis detached, the pleura pushed outwards if exposed, and the pericardium opened.

Paracentesis may be performed in the 5th left interspace ¾ in from the border of the sternum, in the 6th space close to the sternal edge, or an opening may be made into the pericardium from below after incision of the abdominal wall, but not the peritoneum, in the xiphisternal notch.

Cardiolysis.—*By this term is designated the operation of freeing* the pericardium from adhesions to the chest wall. Under the name "præcordial thoracostomy" a similar procedure involving resection of ribs and costal cartilages has been employed to provide more room for an hypertrophied heart.

Experimental work has shown the possibility of operating upon the orifices of the heart. Division of the stenosed mitral valve has been seriously proposed.

CONTUSIONS AND RUPTURES OF LARGE ARTERIES

The arteries may be damaged by blows upon the skin surface; by constricting or stretching forces; or, in war, by small fragments of projectiles which do not penetrate the vessel wall. The intima

alone may suffer tears or cracks, linear or annular; the media may be partly or completely torn simultaneously; or the whole arterial wall may be torn, with or without complete discontinuity. The intima probably never escapes when the other coats are torn.

These lesions in civil life are most common in arteries already *degenerate or diseased*; *spontaneous rupture, which is rare in peripheral arteries*, may occur at the site of calcareous infiltration or of recent inflammatory softening.

Cracks in the intima, if the only lesions, are probably quickly repaired, being covered in the first place by a small mural thrombus, over which the endothelium rapidly spreads. When the media also is torn, some retraction as well as incurvation of the severed parts occurs; assisted by coagula, which may be quite local or may extend as far as or into adjacent branches, it may be enough, in circular lesions, to occlude the artery. Obliteration may occur at the site at once, or only after dislodgment of the early clot with embolism and obliteration of some branch beyond. The clot may be purely local or may extend peripherally, with progressive occlusion of a long stretch of the vessel. Failing obliteration, aneurysmal dilatation may result. The inner coats may bulge through defects in the adventitia, or the outer layers of the wall yield at the site of defect in the inner.

It is in such cases, too, that the possibility of dissecting aneurysm —met with only in the aorta, and therefore not as a rule resulting *from direct traumatic rupture*—arises. The blood finds its way into the layers of the middle coat, disrupts them longitudinally, and reaches a considerable distance, it may be, from the point of entry before bursting again into the lumen or through the externa. In the former case the intramural hæmatoma may suffer the fate of other arterial hæmatomas, and an endothelial lining may spread throughout the cavity left after coagulation, forming a new blood-channel.

Complete rupture of an artery, as in avulsion of a limb, may result in such retraction and incurvation of the inner coats within the stretched, attenuated, and twisted outer coat and sheath as to bring about hæmostasis. In the case of contusion with open wound of surrounding parts, late hæmorrhage may occur, apart from sepsis, as a result of separation of devitalized tissues in the vessel wall.

In subcutaneous ruptures and incomplete lacerations a hæmatoma, circumscribed or diffuse, usually results In the former case the vascular sheath, with adjacent fibrous and connective tissue, supported by contiguous stable structures, contains the escaping blood long enough to allow play to the reactive agencies which determine hyperplasia of

connective-tissue cells, with formation of continuous fibrous walls, and the ultimate elaboration of a cavity communicating with the arterial stream, lined, to some extent, by endothelium. In its definitive state, if such may be said to occur, this aneurysm, *qua* aneurysm, differs in no essential particular from one of "spontaneous" origin. (*See also* p. 143 *et seq.*)

Where the immediate resistance of the surrounding tissues is insufficient to contain the issuing blood, a diffuse arterial hæmatoma is formed. It spreads widely in the connective-tissue planes, exercising eventually great pressure on all structures, the vessels suffering most severely. Not only is the parent arterial stream cut off, but the collateral supply may be interrupted by simple compression or induced thrombosis. For this reason and because of the liability to embolism alluded to above, gangrene is much more common after contusion or rupture of an artery than after ligature; it occurs in from 30 to 50 per cent. of cases It will be obvious that in this respect injury to the popliteal, the vessel most often injured, proves more serious than similar damage to the femoral, to the axillary more serious than to the humeral, and in general the length, calibre, and exposed position on the one hand; on the other hand, the size of the vascular cleft, the position of branches and the distance at which they reach firm connexions, particularly with bone; or the relation of the vessel to some firm fibrous structure under which it may pass—all of them conditions limiting mobility—predispose to injuries and wounds (Makins).

Symptoms.—The symptoms of a circumscribed arterial hæmatoma (circumscribed traumatic aneurysm), as such, differ in no important point from those of aneurysm of "spontaneous" origin (*see* p. 138). It is possible that, if seen at the time of the injury, a tender, elongated, indurated mass may be palpable in the course of the artery; frequently, however, the fact of damage to a large trunk is unrecognized.

A diffuse arterial hæmatoma gives rise to an increasing swelling of the limb, which quickly grows cold; livid and shiny in the early stages, it becomes later waxy-white; extensive ecchymoses may be present. Pain is severe; there may be paroxysmal cramps and odd paræsthesiæ. Though temporary arrests of increase may occur, the progress is usually steady. Expansile pulsation may be observed, and occasionally a local systolic souffle is to be detected. For the first few days it may be shrill and loud, and audible for some distance in the course of the vessel peripherally but not far centrally. The character of the bruit is dependent partly on the force of the blood-stream, but even more on the size and marginal irregularity of the opening in the artery. As the ragged edges become smoothed off with cicatrization the murmur tends to become softer and deeper in tone. Signs of

gangrene may appear in twenty-four hours, or only after the lapse of seventy-two hours or more. In exceptional cases recovery is observed, but defects of nutrition and peripheral nervous disturbances remain.

Diagnosis is not always simple, since, for example, a large artery may be temporarily compressed by fragments of a fractured bone, or by a dislocated bone, and the circulation below thus interrupted; if there be considerable swelling at the same time from injury to other soft parts, doubts may arise. An undoubted hæmatoma under very great tension always arouses suspicion of severe arterial lesion. Rupture of a large branch, or its detachment from the parent stem, of course gives rise to similar phenomena.

The accidents responsible for arterial injuries in civil life are almost always very severe, such as machinery or buffer accidents, " run-overs," bullet impacts, and only rarely penetrating wounds in which the entering body compresses an artery against bone.

Treatment.—A diffuse arterial hæmatoma is a grave injury. Mere loss of blood may be considerable, especially in such a situation as the axilla; the effusion may cause serious damage to the surrounding tissues, in addition to that inflicted in many cases by the causal injury. The menace is gangrene.

Proximal ligature, although it has often been practised, offers fresh risk of gangrene from interruption of a main trunk at two sites. On the other hand, direct intervention on the hæmatoma after temporary compression or ligation of the trunk, turning out the clots—the practice dictated by general principles—may present great practical difficulties, and therefore be inexpedient in the circumstances in which operation is demanded; it should, however, be the routine procedure. Operation should be immediate, but, if postponed for any reason beyond three days, treatment should then be expectant unless there be definite increase of the hæmatoma, obliteration of the peripheral pulse, evidence of injurious pressure on neighbouring structures or organs, or signs of infection. It is unwise to operate if there has been recent severe external hæmorrhage.

In some cases repair or anastomosis of the injured vessel may prove practicable; indeed, so far as the vessel itself is concerned, since it is presumably healthy, arteriorrhaphy in some form should be the purpose of the operator, but double ligation is often necessary.

Amputation may be demanded.

The treatment of a circumscribed traumatic aneurysm is set forth below (p 139)

Wounds of arteries **by sharp weapons or bullets** may give rise to conditions closely analogous to those just dealt with, for, while the presence of a wound of soft parts leading down

to the vessel is important in that the element of infection is often introduced, unless it be wide or gaping the wound does not afford egress to the mass of effused blood. An oblique or transverse wound bleeds more copiously and persistently than a longitudinal one, and even than complete severance, because the elastic and muscular retraction and contraction pull asunder the edges of the wound, instead of occluding the lumen; the persistence of even a mere strip of vessel wall between the retracted open ends of an almost severed artery suffices to maintain bleeding that would otherwise have been arrested, and thus is a material factor in the production of arterial hæmatomas and traumatic aneurysms.

The signs, symptoms, and treatment are similar to the above; the presence of the wound, and the direction of its production if known or deducible, afford some help in diagnosis as to site.

CONTUSIONS AND WOUNDS OF VEINS

These occur in similar circumstances to those of arteries, but in the absence of sepsis the consequences are almost unimportant, except in cases of phlebectasis in, for example, the loose tissues of the vulva, where considerable hæmatomas may occur; or of the cranial sinuses, where pressure phenomena may be serious; or when the bleeding takes place into a serous cavity such as the pleura or the peritoneum.

Thrombosis after contusion is even more common than in arteries, but repair of partial wounds may occur without obliteration, and aseptic obliteration is rarely serious owing to the multiplicity of venous channels. Embolism is not frequent, but in the presence of sepsis the danger of dissemination may call for ligation on the cardiac side.

If the wound of vein be simultaneous with that of the adjacent artery, an arterio-venous aneurysm may result.

Spontaneous rupture of veins is met with in superficial phlebectasis; when there is adherence to the skin the external hæmorrhage may be serious.

AIR IN VEINS

The entry of air into veins, most common in veins of the neck or others subject to the immediate aspiration effects of the thoracic movements, but also reported in the case of uterine, vesical, and other peripheral veins, is of grave moment when considerable in volume

At the moment of entry an intermittent whistling or bubbling or sucking may be audible; critical dyspnœa with tumultuous cardiac urgency supervenes with cyanosis or pallor, and dilatation of the pupils with jactitations or convulsive movement, quickly culminating in

death; but in spite of minatory symptoms recovery may ensue if the amount of air entering has not been great.

The action of the air is probably mechanical; rapidity of entry is an important factor, for the accession to the heart of air in quantity deranges *the valvular apparatus and nullifies the muscular* contractions.

Treatment.—Operations in the neck should be conducted without traction upon the large venous trunks; all large branches should be clamped before division. At the first suggestion of the suction sound, a finger should be placed on the lowest available point of the venous trunk, and the wound should be filled with saline solution. *Artificial respiration is probably of value only so far as* the compression during expiration may succeed in expressing or facilitating the escape of the air. If the symptoms show no sign of amelioration, either cardiac massage or aspiration of the right heart, which is generally dilated, immediately to the left of the sternum in the 4th interspace, has been recommended.

LIGATURE OF ARTERIES IN THEIR CONTINUITY

The ligature material should be of silk, catgut, kangaroo-tail tendon, or ox-aorta. Probably salicylic floss-silk is the best material for the largest vessels: it is sterilizable by boiling, smooth, pliable, and strong. The size *of the ligature must be proportionate to that of the artery to be tied*; that is, also, to the blood-pressure it will have to sustain.

The wound, which is usually made in the line of the vessel, must be long enough to permit all necessary manipulations, without violence, and should not be "tailed"—i.e. the deeper tissues must be divided to an extent equal to that of the skin incision; a dry wound is essential. In deepening the wound the landmark structures should be sought and identified in deliberate succession, without direct reference to the artery until it is reached. When the sheath is adequately exposed, a small opening is made into it *with the flat of the knife held parallel to the arterial axis*; the edge of the wound in the sheath is held steadily aside while a little gutter is deepened between sheath and vessel, well down to the back; the other side is similarly treated, and the aneurysm needle is then gently insinuated round the vessel, its point hugging the arterial wall. Any cellular tissue pushed before it as it passes from the fixed sheath-wound round to the other side, the lip of which is now fixed with forceps for its reception, is to be freed by knife or forceps, permitting free exposure of the eye. The needle is then threaded and withdrawn. In a few cases of large, deeply situated *vessels the aneurysm needle may be threaded before passage*; it is always passed *from* the most important adjacent structure—generally the accompanying vein.

Before tying the ligature, the artery should be compressed against it, so that an assistant may verify the abolition of the pulse at the desired site. The knot should be a reef knot, firmly tied. Formerly it was the rule to tie ligatures tightly enough to lacerate the inner and perhaps the middle coats, and though this is unnecessary to secure occlusion, many surgeons deliberately—and most, in fact, do—divide at least the intima.

After ligature the soft parts are approximated, the wound is closed, and the part placed in such a position as to give as perfect relaxation of the vessel as comfort and convenience permit.

A limb must be kept warm by careful wrappings and protected artificial heat. Morphia may be advisable.

Occlusion of main arteries gives rise to certain immediate effects of no very great moment, and to remote results often grave and persistent. There may be local pallor and fall of temperature; diminished common sensation with subjective disturbance; loss of muscular power, which may be a mere fugitive paresis or actual paralysis. When resulting from wounds there may, of course, be associated damage to nerve-trunks, and the relative shares of such injury and of ischæmia in the production of the signs and symptoms is difficult to disentangle. Nor is it at present certain what may be the effect of interrupting the perivascular nerve-plexuses and vaso-motor nerves. In any case, the volume of a limb remains less, the distal pulse never becomes normal in volume, and the local blood-pressure remains less than the normal after ligation of the main trunk.

There is observed an increase in the firmness of muscles, which at first show œdema and later a degenerative change analogous to that seen in rigor mortis, and there is limitation of freedom and activity of movement. Similarly, joint-movement may be restricted by periarticular œdema and infiltration. Even where recovery appears complete there is permanent decrease in circumference of the limb. Finally, anæmic gangrene may result, and does so in some 10 per cent. of cases. (Makins)

SUTURE OF ARTERIES

Vascular suture was brought within the scope of practical surgery by the recognition of certain indispensable conditions, of which the first and foremost is absolute asepsis. Next in importance is the employment of vaselin or liquid paraffin or some similar emollient to impregnate the suture material, which should be fine silk such as Japanese 0000, with needles to match. [illegible]
use. [illegible]
trate [illegible]
less the amount of the suture material exposed to the blood-stream the better.

Artificial aids to end-to-end suture have been employed, but the tendency here, as in other departments of surgery, is to discard mechanical apparatus and rely upon suture alone. The method of Carrell and Stich has found most favour. They introduce fixation sutures at two or three equidistant points of the circumference of the vessels to be sutured; by traction upon these the approximated everted edges of the cut arterial segments can be successively presented for suture by continuous, or discontinuous U-, mattress, or running stitches. In a healthy artery, if there be little tension on the sutured vessel, if as little as practicable of the vessel be separated from its sheath and supporting tissues, if fine vaselined sutures be applied at intervals of a millimetre or less, without undue tension, repair or junction of arterial tissues may, in the absence of infection, be secured without fear of hæmorrhage or of aneurysmal dilatation. Nor, under these conditions, will thrombosis occur, or rather, it will be limited to a minute mural thrombus at the site of approximation, which will quickly be endothelialized. If the artery be not healthy, if it be damaged in the manipulation, or if micro-organisms obtain access, thrombosis will almost certainly occur, though it may be delayed for hours, days, or longer.

In experimental conditions vascular suture has been employed with such certainty and success as to permit of transplantation of limbs, organs, and considerable portions of a body, to new sites in the individual and even to other individuals. The aorta of a cat may be divided and reunited by suture without disturbing the course of pregnancy.

In man, conditions demanding vascular suture arise with no great frequency, except in war. Aseptic wounds of arteries, if operated upon before thrombosis has occurred, may permit of lateral suture or of end-to-end anastomosis, with or without excision of the damaged or thrombosed segment. In the treatment of aneurysm, particularly that of traumatic origin, i e. where the vessel itself is not diseased, suture of the orifice of communication may be called for, and in certain cases of excision anastomosis may be possible. Where approximation is impossible, a segment of a suitable vein may be grafted between the separated arterial ends. Under experi-
the patency
n permits of
purpose may
be served by the Tuffier paraffin-coated silver tube, which will maintain a
gradua" ; from hours up to as much
as ten should be at the end of the
fourth the collateral circulation is
postponed.

The practical possibility of repairing incised wounds of arteries has led to deliberate operation upon them for conditions due to arterial embolism and thrombosis. When the site of an embolus can be diagnosed, as it may be with some approach to accuracy on the ground of probabilities, the site of pain, or possibly by Moskowicz's test—absence of inhibitory vaso-motor flush after artificial ischæmia in a limb—the artery may be incised, the clot extracted, and the wound sutured. Obviously such an intervention must be immediate or very early.

Operations upon diseased arteries the subject of thrombosis are less satisfactory, for though the clot may be extracted, aspirated, or washed out by the blood-stream after "catheterization" of the vessel up to circulating blood, yet re-formation of clot is prompt and seemingly inevitable. Trendelenburg and others have incised the pulmonary artery for the extraction of impacted massive clot derived from peripheral veins, and have attained operative successes.

In certain conditions of obliterative arteritis in the lower limb, with threatening or commencing gangrene, diversion of the arterial stream into the peripheral venous track has been successfully accomplished. The proximal end of the vein is occluded. The peripheral venous segment may be united to the proximal arterial by circular suture, or, without dividing the artery, a lateral anastomosis between the artery and the vein after ligature of its cut end may be performed. That arterial blood will reach the capillaries in this way is known, but in some at least of the cases calling for such measures the disease is not limited to the arterial side of the vascular tract, and, even if the diversion be temporarily successful, obliteration of the new course eventually occurs. Moreover, it seems possible that
store due
in fact,
circula-
re, after
ligation of the main arterial trunk. If this in fact be the *modus operandi*, the result would be more simply obtained by merely occluding the vein.

DISEASES OF THE ARTERIES

Acute inflammation of arteries is a local process determined either by direct extension of an infective focus in the surrounding tissues, or by the lodgment of an infective embolus. All the coats of the vessel may be involved in the resulting exudation, softening, suppuration, and sloughing. Even if the vessel has already been occluded by thrombosis the consequences may be serious, for a clot may be detached by the force of the blood-stream behind it, or may itself disintegrate. Erosion and rupture of the artery, with or without previous aneurysmal dilatation, result in secondary hæmorrhage or in the formation of an arterial hæmatoma that is infected from the outset.

Septic ligatures, ligation in an infected area, the continuous pressure of a drainage-tube in such an area, are the commoner determining causes. In general the arterial walls present a good defence to external attack, even when passing through or forming part of the wall of an abscess cavity.

The etiological factors concerned in *chronic inflammation of arteries* are the circulating toxins, or organisms, which reach the vascular tissues during illnesses such as influenza, erysipelas, scarlet fever, enteric fever, smallpox, acute rheumatism, septicæmia, gonorrhœa, and similar infections; the metabolic poisons associated with gout, diabetes, and renal inadequacy; the effects of poisons such as lead, alcohol, tobacco; and, finally, the less tangible but doubtless common noxæ resulting from defect or derangement or excessive prolongation of the digestive process.

In certain cases specific organisms may be found in lesions of the arterial walls, which then exhibit the typical histological features of tuberculosis, syphilis, or similar morbid processes. The various noxæ betray some evidence of selection in attacking the arterial system, and the difference in anatomical structure in different parts of the body also affects the pathological changes induced.

Decade by decade the *normal arteries show progressive changes*, chiefly in the direction of deterioration of the elastic and muscular elements, with fibroid substitution and hypertrophy of existing fibroid elements; in the later decades, too, fatty and calcareous degenerations may be present. (Fig. 631.) Whilst, in the smaller arteries, the lumen tends to be encroached upon by hyperplasia of the intima, in the largest arteries, on the other hand, the lumen may be somewhat widened. These "normal" changes may occur unduly early in life, or may be excessive, especially in vessels previously the seat of inflammation; and in general are apt to be produced by any conditions which raise permanently, or for long periods, the general arterial pressure, which their own lack of elasticity and

diminution of calibre tend to heighten. In certain cases histological evidence of the basis of these changes in local defect of nutrition is forthcoming in the definite localization of inflammatory exudate with eventual cicatrization around the vasa vasorum, sufficient to diminish materially the blood supply and even to determine de-



Fig. 631.—Calcareous arteries.

A, Tubular calcification of medium-sized vessels Before drying, these vessels were quite pliable. B, Calcareous plaques from abdominal aorta and its primary branches.

(*Westminster Hospital Museum*)

generation or actual local necrosis. The process may be well seen in early cases of atheroma, a disease that in its later stages betrays little indication of a definite inflammatory origin. Discrete areas of *necrotic detritus in the deeper layers of the intima* may burst into the lumen and leave an "ulcer" temporarily at least uncovered

by endothelium. Instead of a fatty or colliquative, a calcareous degeneration may occur, and large plaques or masses of earthy matter may lie in the intima or project into the lumen, freely exposed, or covered by endothelium. Such a vessel may be widely or extensively dilated; or, as to size, be very little affected; or be the seat of aneurysmal dilatation. The calcareous changes are frequently at a maximum about the origin of branches, the lumen of which may be seriously diminished.

Sclerosis of the smaller arteries—a process in which disappearance of the elastic and muscular constituents is generally accompanied by cellular hyperplasia in the intima, either generalized or local, and in certain cases by the appearance of annular or tubular deposits of calcareous material in the media—is of surgical importance, not only as a cause of gangrene but also as bearing upon the fitness of a patient for any operative procedure.

The handicap may arise through defect in the cardio-vascular system itself, or secondarily through deficiency in vital organs such as the kidneys, themselves deranged by defective blood supply. Apart from mere deficiency of blood supply, disease in the arterial walls may pave the way for, or determine, thrombosis, and the definitive form of some arteries with very restricted lumina is probably determined by organization and canalization of thrombi. In this class of cases, which may be distinguished as a *thrombo-angiitis obliterans*, the disorder is not strictly limited to the arteries, but affects in a similar form the other side of the vascular tract, the veins. (Figs. 632, 633)

PHLEBITIS

Acute inflammation of veins, as of arteries, is occasioned by the extension of a local inflammatory process from without, by direct infection, or by infective agents reaching the vein walls through vasa vasorum and possibly by the contained stream. It is more particularly in the course of, or as a sequel to, infectious and specific fevers, or after operations, that phlebitis is met with in surgical practice, but its occurrence in anæmias and cachectic states, in varicose veins and phlebectases, in the gouty, and in other conditions, where no infective focus is manifest, suggests that the quality of the circulating blood, retardation of the stream, or stasis, and non-bacterial poisons have, as is known from experimental observation, an important rôle to play.

The walls of the larger veins, like those of arteries, preserve their integrity well in the presence of pus, but infiltration, softening, and erosion occur. In the case of the veins, however, thrombosis and clotting ensue much more readily, and there is, moreover, but a

minimal pressure on the clot, hence venous hæmorrhage as a secondary result of sepsis is proportionately less common than arterial.

The clinical signs of phlebitis cannot be discriminated from the accompanying thrombosis. When the affected vessels are superficial, pain and tenderness in the course of the vessel, with a reddened skin of texture less supple than normal, overlying an elongated, indurated cord or mass, are evident. When deeper and larger vessels

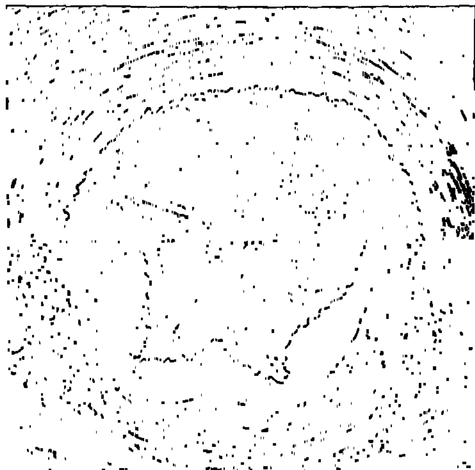


Fig. 632.—From a case of symmetrical, but not simultaneous, gangrene of the legs in a Russian Jew.

The upper section shows an earlier stage of the secondary thrombosis than that exhibited in the lower section. The figure does not display the affection of the vasa vasorum and small vessels of the immediate neighbourhood, which were enormously thickened; relatively much more as regards the interna. The veins were as much affected as the arteries.

(*Westminster Hospital Laboratories*, C R, 5, 151)

are involved, cramps, subjective sensation of weight, and palsy, obvious œdema and swelling, perhaps with dilatation of superficial veins, are characteristic. The extent of a vein involved may be definitely restricted, or a whole trunk may suffer simultaneously or

progressively, and multiple areas in the course of one trunk may suffer together or in succession. Extension may occur from the periphery towards the heart, or, the primary block occurring in a large trunk, clotting may proceed towards the periphery. When the phlebitis is of acute infective origin, the clot also will be infected, will suppurate and disintegrate in part or wholly. If the local



Fig. 633.—The accompanying vein. (*See* Fig. 632.)

abscess be recognized in time, evacuated and efficiently drained, the disintegration may be arrested and the clot, at a distance on either side, remain either to organize and obliterate, or canalize and re-establish the channel. Otherwise, with the disintegration of the infected clot dissemination occurs with resultant embolism and pyæmia.

Postoperative thrombosis (Fig. 631) is now generally looked upon as due *to sepsis. The operation wound may heal by first intention, or* may of necessity be septic, as in intervention for infection in the peri-

toneal cavity. In the former case the infective focus is at a distance, such as carious teeth, sinusitis, otitis, furunculosis, gonorrhœa—conditions not necessarily associated with obvious constitutional disturbance; or, in spite of the healing by first intention, organisms of low virulence may in fact be in the wound; or an intercurrent illness such as influenza or pneumonia may provide the toxin. The thrombus is generally in the leg, usually in the femoral or saphenous vein; more often on the left side; and is particularly to be guarded against when varicosity exists. Such thromboses run a benign course, as a rule, but call for three to six weeks of recumbency with absolute rest; so long as there is elevation of temperature, so long as pulse-rate is high in proportion to temperature, extension of existing clotting or secondary occurrence of thrombosis is to be feared. A steady rise of pulse-rate, without corresponding rise of temperature, should, in the absence of some proximate cause, arouse suspicion of commencing *thrombosis*. Especially in the presence of sepsis, where no adequate cause for a remittent or intermittent fever can be found, should septic thrombosis be borne in mind; ligation of affected veins draining the site of a suppurative appendix, of the uterine and ovarian veins as in puerperal sepsis, and of others in analogous conditions is sometimes called for. The more severe forms, such as pylephlebitis, belong to the domain of pyæmia.[1]



Fig. 634. — Thrombosis of the external and common iliac veins, and of the vena cava.

The coagulum in the vena cava is much more recent than that in the iliac veins. The iliac arteries and aorta had many small atheromatous plaques.

(*Westminster Hospital Museum*)

The most formidable danger is embolism, with pulmonary blockade and sudden death—a by no means rare occurrence. Smaller emboli give rise to sudden agonizing pains in the chest with cyanosis and appalling subjective anxiety. Immediate inhalation of oxygen, and morphia when the urgency is relieved, are the remedies.

Treatment for simple thrombosis consists in keeping the limb at rest, well wrapped

[1] *See* Vol I, p. 376.

up, and cushioned. Citric acid in doses of 1 drachm, three or four times in twenty-four hours, is advisable; morphia is in some cases indicated, to overcome pain or to ensure quietude.

Massage, which is called for ultimately, should never be begun until the temperature has been normal for a week, until all the inflammatory signs have disappeared, and in no case before three weeks from the date of onset; even then for a time only the lightest effleurage should be employed.

The clot,[1] which may be quite local, or may occupy the whole length of a venous trunk, is organized from various points in the endothelium, and becomes more or less extensively and intimately adherent to the internal surface. Sometimes the adhesion is close and definitive, so that ultimately a fibrous cord alone remains; at others, considerable spaces are left between the organized clot covered with endothelium, and the endothelial lining of the wall proper, which, together with the channels formed by well-developed blood spaces of new formation amidst the organized tissue, may suffice to conduct a considerable volume of blood once more along the thrombosed track.

In some instances, more particularly in the thrombi occurring in varices, a deposition of lime salts may lead to the formation, generally near valves, of hard nodules, known as phleboliths.

VARICOSE VEINS (VARIX)

Permanent dilatation of a vein constitutes a phlebectasis (Fig. 635). The common situations for the affection are the saphenous tract (where the condition is known as "varix" or varicose veins), the veins of the pampiniform plexus (varicocele) and of the hæmorrhoidal (piles). The veins of the uterine adnexa, of the abdominal wall, and others are occasionally affected.

Pathology.—The middle coats of the veins normally exhibit much less muscular and elastic tissue than those of the arteries, but under conditions of excessive intravenous pressure these tissues hypertrophy and for a time at least remain efficient. Where, for instance, the pressure is the rhythmically alternating tension of the arterial system, the veins become "arterialized," but where the pressure is constant and high, the limit of response is reached, the specialized tissues degenerate and are replaced by fibrous tissue, and the intima proliferates so that a phlebo-sclerosis results. Thus the vessel walls become comparatively rigid, and as the connective tissue of the valves shares in the sclerosis the cusps no longer meet across the dilated lumen, and their function falls into abeyance. In situations such as the saphenous column, where the effects of gravity

[1] For histological details of thrombosis, see Vol. I, pp 133, 134, 182.

are at a maximum, this failure results in a still greater strain on the already inadequate *walls*, and the degeneration of the *middle* coat may *proceed to* an atrophy of the whole wall with accompanying *perivascular hyperplasia*, adhesion, and eventual atrophy of the overlying *skin* if the *vein* be superficial. At *the same time such veins*

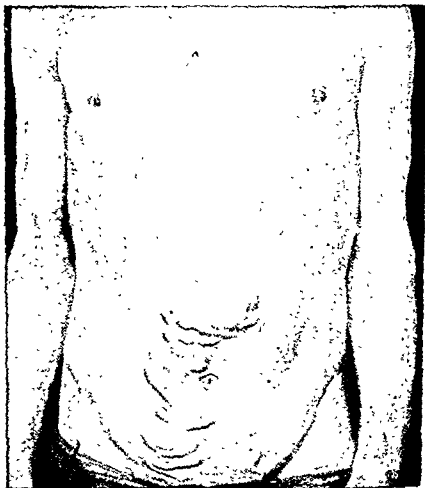


Fig. 635.—*Phlebectasis associated with obstruction of inferior vena cava.*

increase considerably in length, so that they become *tortuous*. The *hæmic and lymphatic* vasa vasorum suffer *to some extent* in the course of the sclerosis, and even the intima therefore becomes less *resistant* to stress and injury, so that phlebitis and thrombosis are not uncommon.

Etiology.—The factors concerned *in the etiology* of *varicose* veins are various. In the typical form *seen in the main saphenous trunk* gravity is the determining influence; occupations which require

long periods of standing and much muscular exertion without walking throw a continued strain upon the valves and conduce to a higher intravenous tension than normal. There is thus always imminent a degree of distension of the lumen that will render the valve incompetent and throw a double stress on the valve below, establishing a vicious circle of added stress and diminished guard which will result in failure of the whole tract. Whilst the first valve failure may possibly be due to an accidental stress, in many instances there is an inherent inadequacy of the vascular tissues Evidence of this is forthcoming in some degree of inherited tendency to the condition, and occasionally in simultaneous or collateral sclerosis of the arterial field. Such a factor should determine widespread incidence, whereas many cases of varicosity are unilateral or even of very limited extent. Inherent inadequacy may be presumed in explanation of the extensive varices of young people; those of the middle-aged are probably largely mechanical in origin.

Simple ligation of a large venous trunk does not lead to varicosity; but obstruction by pressure of a tumour, of the pregnant uterus (Fig. 636), or by local thrombosis may result in varix. In connexion with pregnancy another factor is probably associated, for the dilatation is frequently seen in the early months, and is often not limited to the large veins, but is present also in the small radicals.

Clinically, varices are met with at all ages from childhood to senility, but the majority are seen in early adult years and middle life. They are more frequent in the male sex, notwithstanding the influence of pregnancy. Whilst occasionally present in the upper limb apart from obstruction in the axilla, and in other parts of the body, the vast majority are seen in the lower limb and in one or other of the saphenous tracts, especially the long. The whole trunk may be regularly dilated, without much tortuosity, or here and there in the course there may be discrete local dilatations, or there may be a congeries of tortuous blood-spaces (Figs. 636, 637); the main branches may escape, or may suffer commensurately; the venous radicals may escape, or may be universally or sporadically involved.

Symptoms.—The mere existence of obvious large vessels is a source of worry to some people; most patients present themselves because of aching in the limbs or unduly rapid onset of fatigue; late or severe cases may be first seen when trauma has led to rupture and severe hæmorrhage, or the secondary effects of venous stasis and inadequate tissue drainage upon the cutaneous tissues may induce eczema or chronic ulceration.

Pain, generally a vague aching, but occasionally severe and lancinating, is common; it has been attributed to an associated perineural sclerosis and to varicosity of the endoneural veins. Œdema,

apart from a slight perimalleolar fullness at night, is not a direct result of simple varicosity; it is a common, if not a constant, symptom in old-standing cases where there is chronic catarrh of the skin; where there is stasis, with some effusion of blood as witnessed



Fig. 636.—Varicose veins: extreme dilatation in early months of pregnancy.

by pigmentation of the skin, where there have been attacks of phlebitis, and where the lymphatic system, as is often the case, has shared in the sclerotic process or been involved in the thrombophlebitis. The œdema may be relievable by recumbency and elevation of the limb, or it may be persistent and associated with hypertrophic changes in the skin.

Varicose veins are very susceptible to phlebitis and thrombosis.

Treatment.—Varicose veins call for treatment if giving rise to discomfort or disability, if progressing rapidly, if entrance is sought to the public services, or if secondary consequences arise. Since varices lay a patient open to certain complications, such as phlebitis and thrombosis, circumstances may make prophylactic operation desirable. If, for example, a serious operation is contemplated upon an elderly patient who has large varices, it may be advisable to ligature or excise them immediately before, or as a preliminary to, the graver operation.

Short of operation, all methods of treatment involve artificial support. Where eczema, ulceration, or extensive cicatrices are present it is advisable to begin, after surgical cleanliness, by using Unna's varnish applied with a brush on a thin gauze bandage, a window may be left at the site of ulceration. If there is deep ulceration, or much heaping-up of keratinized epithelium about the ulcer, or if there is much discharge, it is better to use "leno" bandage, which is applied wet and contracts slightly on drying; the surface of the ulcer can be kept clean by washing away discharges through the meshes of the fabric. As soon as ulcers are healed and the skin surface healthy, an elastic web or crêpe bandage may be used. Some patients prefer an elastic stocking, which should fit every part of the leg exactly without compression, the pressure of the elastic only coming into play with the filling of the veins or the onset of swelling.



Fig. 637.—Varicose veins; showing cyst-like dilatations in upper part of saphenous tracts, and pigmentation of the skin resulting from venous stasis in lower tracts.

Bandages should only exert very slight pressure, and must be evenly rolled on. Stockings, if they cover the knee, should have a stiffening of leather up the ham to prevent creasing; they need a brace to keep the upper part of the thigh-piece in place.

Operation is advised where failure of the valves is an obvious feature of the case; where ulceration or degeneration of the cutis is intractable; where thrombosis is extant or recurrent; where local varices are painful or annoying; where varices preclude admission to some public service.

Failure of the valves can be demonstrated by Trendelenburg's test—emptying the veins of blood, closing the saphenous trunk at the upper end by pressure whilst the patient is recumbent, and then observing the effect of the assumption of the erect posture. If the vein fills suddenly when the pressure is removed, by the descent of a column of blood, the patient will be benefited by ligature of the main trunk.

The operations commonly performed are excision of portions of the main trunk at intervals along its course, with ligation of branches; removal of considerable lengths by means of an extractor (Mayo); excision of local congeries of phlebectases, sometimes with a portion of the overlying skin (Fig. 638); spiral incision of the parts down to the deep fascia; anastomosis of the divided and ligated saphenous trunk laterally into the femoral vein below the first set of valves.

After operation the patient should be kept in bed for two to three weeks, and when first allowed up should have an Unna's dressing applied for a week.

Operation is not a "cure," inasmuch as it does not remove the inherent defect of the vascular tissues or protect the whole venous system of a limb from the direct effect of gravity or abnormal pressure; a second operation may be required later for newly developed varices. For those phlebectases, however, which are of the nature of venous angiomas operation may prove a lasting remedy, and in general it may be said that a well-planned operation effects so great an amelioration as to be tantamount to "cure."

ANEURYSM

An aneurysm is a circumscribed hollow tumour, the cavity of which contains blood and communicates with the lumen of an artery.

Etiology.—Aneurysms occur at all ages, but are most common between the thirtieth and fiftieth years. Of 2,196 aneurysms, 622 occurred between 40 and 50, only 41 before 20, and 39 after 70. Men are more liable than women in the proportion of about 8 to 1. It is pre-eminently a d[illegible] [illegible]perate climates; the Anglo-Saxon peoples appear to show [illegible] [illegible]ence-rate, but racial

influences are probably of little moment. Among the diseases causing aneurysm, syphilis is predominant.

Surgical aneurysms—that is, those amenable to operative treatment—are comparatively rare lesions.

Morbid anatomy.—Aneurysms vary in size from that of a small shot to a tumour of many pints capacity. The shape of small aneurysms is generally a regular ovoid, whilst the contour of larger ones is almost always irregularly globose. (Fig. 639.) The lumen of large arteries in certain diseased states may be extensively dilated, constituting an arteriectasis; and occasionally a local dilatation, affecting the entire circumference uniformly over a limited area, may give rise to a "fusiform" aneurysm, but the condition is rare. The walls are seldom of equal thickness throughout the tumour; in a majority of cases elements derived from all the coats of the artery can be traced in the proximal parts of the aneurysmal walls; even in large aneurysms the endothelium may extend over a considerable part of the interior. The other constituents of the tunica intima, and those of the externa, can also be found at a distance from the parent artery, but those of the media, elastic tissue and muscle, are conspicuous by their absence, except in the immediate vicinity of the orifice of communication or in very small aneurysms.

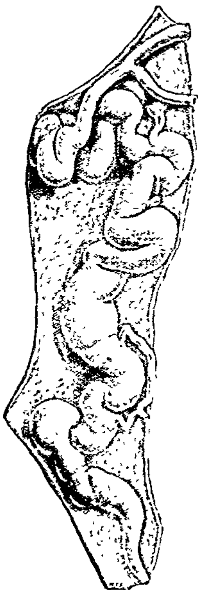


Fig. 638.—Varicose internal saphenous vein, removed with overlying skin, and hardened with contained blood.

(*Westminster Hospital Museum.*)

The substance of the walls is derived by proliferation from the *connective tissues in the vicinity* of a growing aneurysm. Except in the early stages of formation the walls are poorly vascularized; they are inseparably connected with surrounding tissues and structures, which have

been partly or wholly enveloped in new connective tissue and ultimately incorporated; resistant tissues such as bone and cartilage encountered in the course of extension may project into the cavity uncovered by new connective tissue, but the exposed surface exhibits the effects of pressure erosion. No tissues are exempt from the pressure effects: the walls of hollow viscera are thinned and ultimately perforated; the skin when reached becomes stretched and



Fig. 639—Aneurysm of common carotid.
(*C. C. Choyce's case.*)

attenuated; the capsule of a joint may yield; the spinal canal may be opened; communication may be established with other blood-vessels.

The orifice of communication may occupy but a small part of the circumference of the parent vessel; in the case of certain aneurysms of fusiform shape, which are almost invariably small, there may be two openings at opposite poles; the artery may communicate with the sac by two openings close to one another, connected or not by a groove which represents the original channel of the blood-stream.

Other arteries, which represent original branches from the diseased site and their connexions, or vessels of new formation, may open from some part of the sac wall.

Contents.—The contents of small aneurysms may be entirely fluid blood, but in the larger there is always a greater or less amount of clot; some of it is red, some greyish-white or brownish; all, except the very recent, is laminated, and the peripheral laminæ, which were the earliest formed, are of smaller area individually than those of more recent formation; the "white" laminæ probably arise as mural thrombi, are rich in white blood-corpuscles, become vascularized from the walls, and later undergo fatty and hyaline degeneration. As the aneurysm enlarges, laminæ split or become detached at some point, so that fluid blood finds its way into rifts in the white clot, and forms red coagula In the later stages, when there is a large irregular surface uncovered by intimal cells in contact with oscillating blood, considerable masses of red clot are formed towards the lumen of the cavity. Sometimes cyst-like spaces containing serum are found among the older coagula, and masses of pigment may be detected. In some instances the whole cavity of the aneurysm may be filled with clot of various types; in this case the artery itself will usually be found thrombosed in the immediate vicinity of the orifice.

Pathology.—The walls of a normal artery have an ample reserve of strength beyond the requirements of ordinary blood-pressure. Preservation of their calibre is dependent on the muscular and elastic elements which predominate in the middle coat; in health, these tissues are unaffected by the rhythmic variations of pressure to which they are subjected. Nutrition of the media and peripheral parts of the intima is effected from the vessels which ramify in the externa, probably by lymphatic transudation, since in healthy vessels the vasa vasorum can only be traced into the peripheral parts of the media. In inflammatory conditions, as may be seen in the aorta to best advantage, the vasa vasorum are dilated; they can be traced deeply into the media, and are the centres of well-marked round-celled infiltration The fate of inflammatory exudate in the arterial walls is not dissimilar to that elsewhere; it may be absorbed, but usually it is, in part at least, organized; by its mere amount and osmotic pressure, or by the toxic effects of associated organisms, it may cause local necrosis. Of inflammations so trivial as to permit *restitutio ad integrum* practically nothing is known except by analogy; purulent inflammations are a part either of pyæmia or direct local infections; the great majority of inflammations of arteries are of the type which leads, during the stage of œdema and exudation, to softening of the tissues, and later, in the stage of "repair," to fibrosis,

been partly or wholly enveloped in new connective tissue and ultimately incorporated; resistant tissues such as bone and cartilage encountered in the course of extension may project into the cavity uncovered by new connective tissue, but the exposed surface exhibits the effects of pressure erosion. No tissues are exempt from the pressure effects: the walls of hollow viscera are thinned and ultimately perforated; the skin when reached becomes stretched and



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Other arteries, which represent original branches from the diseased site and their connexions, or vessels of new formation, may open from some part of the sac wall.

Contents.—The contents of small aneurysms may be entirely fluid blood, but in the larger there is always a greater or less amount of clot; some of it is red, some greyish-white or brownish; all, except the very recent, is laminated, and the peripheral laminæ, which were the earliest formed, are of smaller area individually than those of more recent formation; the "white" laminæ probably arise as mural thrombi, are rich in white blood-corpuscles, become vascularized from the walls, and later undergo fatty and hyaline degeneration. As the aneurysm enlarges, laminæ split or become detached at some point, so that fluid blood finds its way into rifts in the white clot, and forms red coagula. In the later stages, when there is a large irregular surface uncovered by intimal cells in contact with oscillating blood, considerable masses of red clot are formed towards the lumen of the cavity. Sometimes cyst-like spaces containing serum are found among the older coagula, and masses of pigment may be detected. In some instances the whole cavity of the aneurysm may be filled with clot of various types; in this case the artery itself will usually be found thrombosed in the immediate vicinity of the orifice.

Pathology.—The walls of a normal artery have an ample reserve of strength beyond the requirements of ordinary blood-pressure. Preservation of their calibre is dependent on the muscular and elastic elements which predominate in the middle coat; in health, these tissues are unaffected by the rhythmic variations of pressure to which they are subjected. Nutrition of the media and peripheral parts of the intima is effected from the vessels which ramify in the externa, probably by lymphatic transudation, since in healthy vessels the vasa vasorum can only be traced into the peripheral parts of the media. In inflammatory conditions, as may be seen in the aorta to best advantage, the vasa vasorum are dilated; they can be traced deeply into the media, and are the centres of well-marked round-celled infiltration. The fate of inflammatory exudate in the arterial walls is not dissimilar to that elsewhere; it may be absorbed, but usually it is, in part at least, organized; by its mere amount and osmotic pressure, or by the toxic effects of associated organisms, it may cause local necrosis. Of inflammations so trivial as to permit *restitutio ad integrum* practically nothing is known except by analogy; purulent inflammations are a part either of pyæmia or direct local infections; the great majority of inflammations of arteries are of the type which leads, during the stage of œdema and exudation, to softening of the tissues, and later, in the stage of "repair," to fibrosis,

which, either by its extent or from its localization about the nutrient vessels, eventuates in deterioration of the *function of the more specialized* tissues such as muscle and elastic fibres. Toxins, whether of mycotic or of metabolic origin, produce effects of two classes upon the arterial walls: they lead, on the one hand, to proliferation of connective-tissue cells, which is seen at a maximum in the deeper parts of the intima and may there assume extreme proportions; on the other hand, to degenerations which particularly affect muscle and elastic elements, but may also produce local necrosis beneath the intima, and the formation of calcareous deposits either of annular distribution in the media or of irregular arrangement in plaques in the intima.

The total effect of these tissue changes is to diminish the *functional capacity of the walls in relation to the strains impressed upon* them by the circulating blood at its maximal variations of pressure, as well as to the stresses imposed by extreme bodily movements and by external trauma. Thus it comes about that syphilis, gonorrhœa, other infections, and chronic alcoholism are very common antecedents of aneurysmal dilatation.

A constant high blood-pressure has apparently but little if any influence in the causation of aneurysm; but sudden rise of pressure, such as may be associated with violent bodily exertion or emotion, more particularly in those who ordinarily lead sedentary and serene lives, is a serious menace to those with deteriorated arterial tissues.

The *intima*—and perhaps the *media also*—*particularly of diseased* arteries, does indeed show histological evidence of repeated small traumata such as might result from stretching and bending forces operating during strenuous bodily movements and exertions, or from local increase in the blood-pressure, they are sufficient to weaken the coats, temporarily at any rate, and presumably form the initial or the determining cause of aneurysms. Thus, whilst the morbid processes concerned in the production of aneurysm are in the main equally incident upon the whole arterial system, aneurysms are in the majority of cases single; they may be symmetrical, and they may be multiple, but some external factor is wanting, and is probably to be found in trauma.

Where the inflammatory process in the arterial wall results from septic embolus, or is a direct invasion from without, the softening of the tissues may be such as to lead, even under normal conditions of blood-pressure, to rapid dilatation and formation of "acute" aneurysms. The embolic type, due, as a rule, to infective endocarditis, occurs not infrequently in children and young people, is often multiple, and progresses rapidly towards rupture.

Course.—Some aneurysms develop rapidly, but the majority are of insidious growth. Enlargement is along the path of least resistance to pressure, will be rapid amongst loose tissues, extremely slow where bone, for example, opposes advance; as a consequence of the fluid distribution of the producing pressure, increase will be more rapid in larger sacs; from the nature of the walls it results that extension is rapid at one part of the sac, slow at another. Secondary sacs, which may become merged in the main cavity later, are formed by ruptures of slight extent which permit escape of blood into adjacent loose tissue, there to clot and stimulate the formation of new connective-tissue walls.

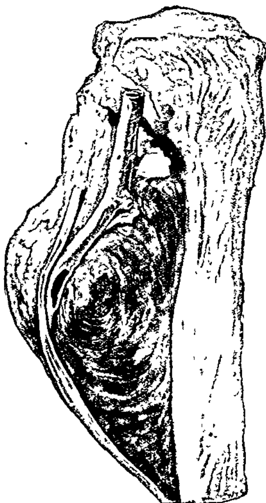


Fig. 640.—Aneurysm of posterior tibial artery; rupture; circumscribed arterial hæmatoma. Note the posterior tibial nerve and vein stretched over the mass of coagulum.

The majority of aneurysms terminate by rupture (Fig. 640) among the tissues or into some viscus or, rarely, on the skin surface, rupture into the stomach or intestines, into the œsophagus or trachea, or into a vein, is frequent. Rupture may be determined by direct injury. In some instances death may result from pressure on a vital part.

Rarely, aneurysms undergo spontaneous cure, almost always by extension of clotting to the artery, either as a result of an embolus lodged in the mouth or in the artery below, or from local thrombosis. Spontaneous cure by coagulation—obliteration without interruption of the stream in the parent artery—is a rare

exception, but may occur in favourable general circumstances if the orifice of communication be relatively very small. It has been alleged that an aneurysm in the course of development may come to press upon the artery of supply and cut off the stream; it can do so only by determining changes in the wall at the site of contact, with resultant thrombosis. Suppuration may occur in and around a sac partly or completely filled with clot; it may result from extension of infection directly, or in the course of a general infection, or as a reawakening of a quiescent focus of the organisms responsible for the original local disease of the artery. In some instances the result of suppuration in the sac has been thrombosis of the artery and cure; more often it determines rupture and hæmorrhage, perhaps fatal. Suppuration occasionally occurs in aneurysms cured by means that leave the sac and its contents undisturbed, even after the lapse of a considerable period.

Inflammation about an aneurysm is accompanied by increase in the size of the tumour and in the amplitude of the pulsations. There may be local pain, redness and œdema, or tension and glazing, of the overlying skin, eventuating in obvious indications of suppuration. Bursting or incision of the abscess will be accompanied by massive hæmorrhage unless competent clotting of the artery has already occurred. Temporary proximal control of the trunk, wide exposure and evacuation of the sac, double ligature *in situ* if the tissues be not too necrotic, irrigation and tamponade may suffice to effect cure. Proximal ligation, and even consecutive amputation, may be the only resource.

Signs and symptoms.—The symptoms of an aneurysm are referable almost entirely to the pressure effects, the clinical signs are attributable partly to them and partly to the peculiar qualities of the tumour. In accessible parts intermittent expansion of cardiac rhythm can be felt; pulsation is visible either to the naked eye or upon the Röntgen screen. The position of the tumour, in the earlier stages, has definite relation to the course of some artery; the tumour itself may be compressible. A bruit is to be heard over the tumour, systolic in time; sometimes it is traceable in the distal course of the artery. The pulse below the aneurysm may be smaller than that in the corresponding vessel of the opposite side, and the pulse-wave, as recognized by the sphygmograph, may be delayed.

The pulsation and the bruit can be modified, if the aneurysm be in a limb, by elevation of the part, or by proximal compression of the main trunk if accessible. Compressibility of the tumour diminishes with increase in the amount of contained clot. Pulsation may be imperceptible or absent if the sac be largely filled with firm coagula.

Pressure upon nerves leads to pain which may be of the most

agonizing description; paralyses of the extremities, with contractures, are dependent partly upon nerve pressure, partly upon muscular atrophy, displacement of tendons, involvement of joints, or mere size of the tumour. The recurrent laryngeal nerve is often involved by aneurysms, and the corresponding vocal cord paralysed. Compression of vessels leads to œdema of the limbs or of the neck and head. Proptosis, dysphagia, dyspnœa, pulmonary collapse and œdema, gastric and intestinal disturbances, and similar phenomena are occasioned by aneurysms of particular vessels.

Treatment.—The object of treatment is to avert the dangers of rupture and gangrene, and to arrest or relieve the pressure effects without prejudice to the circulation. The ideal aimed at is removal of the tumour without damage to other structures, and permanent re-establishment of circulation in the affected trunk: it can be attained only when the aneurysm is of moderate size and accessible, the artery not the seat of extensive disease, and the patient otherwise healthy.

In point of fact, until recent years all methods of treatment, operative and other, aimed at "cure" by determining **clotting in the sac**, with or without simultaneous obliteration of the parent trunk. Attack has been made through the blood itself, by exalting coagulability and providing the most favourable circumstances possible for clotting; or by direct stimulation of coagulation within the sac. Thus, absolute rest in bed, with a minimum of disturbance for necessary nursing measures, prolonged over periods of weeks or months, and accompanied by a reduction of nutrition to the extreme point of endurance, has been combined with the exhibition of drugs such as iodide of potassium in maximal doses, and gelatin administered in 2-per-cent. sterilized solution in normal saline intramuscularly, in doses of 150 to 200 c c. Amelioration of symptoms, arrest of progress in the aneurysm, and even "cures" have been reported. Nowadays this method is employed only where more direct attack is precluded either by reason of the site of the aneurysm, the age or condition of the patient, the absence of facilities for, or consent to, operation.

Much the same may be said of the methods involving direct stimulation of clotting within the sac.

Acupuncture, practised by Macewen and Cimselli, and employed for aortic, or peripheral aneurysms otherwise inoperable, aims at determining clotting in the sac by damaging the intima—a principle utilized more recently in the method of "searing" the intima by a powerful current passed through wire introduced into the sac, and manipulated into contact with the walls. This method has not found favour with surgeons generally, but, considering the nature of the cases properly selected for its use, it can claim some success.

Clotting may be induced by the introduction of quantities of

foreign material into a sac through a fine cannula. Wire is generally employed (*method of Moore and D'Arcy Power*), and is previously so wound or sprung as to expand within the sac and form a widespread scaffolding for clot. There is a danger of the passage of wire into large vessels, sometimes far afield, or into the heart.

Wire so introduced may be made the negative pole of an electrolytic circuit, and clotting thus determined. Mediate galvanization without any intrasaccular electrode has also been employed.

The surgical methods practised have been very numerous, and some which are only used occasionally must be mentioned.

Compression may be digital, instrumental, or elastic *Direct* pressure, made upon the tumour itself, is now abandoned as a sole method, since it is apt to cause embolism or internal rupture. By *indirect* pressure the trunk is controlled at a distance either by the finger or by an instrument specially devised. Such compression should, if possible, be complete and constant, but may of necessity be incomplete and intermittent, and is usually employed for periods of four to six hours if complete, of twenty-four hours or longer if discontinuous. After the tenth hour of continuous pressure, if there be still pulsation in the sac, the attempt should be abandoned. The dangers are—embolism, from unsteady application; gangrene of the extremities, and, in the case of the aorta, gangrene of the intestines.

Digital compression of the femoral for popliteal aneurysm formerly claimed 80 per cent of cures with only 6 per cent. of gangrene, but the latest figures give much inferior results. The method is difficult, and less certain than other methods in, for example, popliteal aneurysm, and too dangerous in abdominal aneurysm, but, as a preliminary measure for development of collateral circulation, may be a valuable resource.

Reid's method of elastic compression below, over, and above the sac, maintained under anæsthesia for one to three and a half hours, and followed by proximal digital compression, under narcotics, of many hours' duration, was alleged to give 48 per cent. of cures, but admitted 12 per cent. of gangrenes, in some cases with rupture of the sac.

Ligature.—The object of this method of treatment of aneurysm is to secure obliteration of the sac by clotting; it aims, therefore, not at complete interruption of access of blood, but at such a diminution of the flow and reduction of the range and power of oscillation as will allow of enough blood reaching the sac to supply the requisite clot to fill it, after the initial coagulation, that follows on the sudden cessation of flow, has occurred. Ligature may be proximal, with intervention of a branch; between the sac and the nearest branch; immediately beyond; or at a distance below the first branch; or it may be both proximal and distal without complete arrest of flow

through the sac; or, after temporary control of the main trunk above and below, the sac may be incised, the orifices of the main vessels discovered, the trunks cleared and ligated, and all other communicating vessels similarly dealt with.

After ligature close to the sac, whether accomplished by opening the sac or not, excision of the tumour may be undertaken, or the empty cavity may be packed and drained.

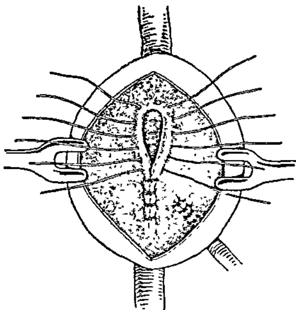


Fig. 641.—Intrasaccular suture of aneurysm. (*After Matas.*) (*See* Fig. 642.)

In favourable circumstances, after excision of the sac it may be possible to reunite the divided ends of the artery by circular suture, or in some traumatic cases it may even be possible to repair the vessel by lateral suture. A graft of vein has been interposed between widely separated portions of an arterial trunk with at least temporary success.

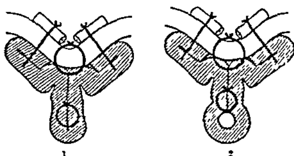


Fig. 642.—Obliterative (1) and non-obliterative (2) endo-aneurysmorrhaphy. (*After Matas.*)

Matas's operation.—Matas has introduced a method of intrasaccular attack upon aneurysms (Figs. 641, 642). It is necessary to control the main trunk above and below, preferably by rubber-covered clamps. The sac is then incised, care being taken to avoid all unnecessary exposure or separation of the wall and not to injure any part of the normal trunk, which may have been rotated towards the surface and course over the tumour to the point of communication. The sac is emptied

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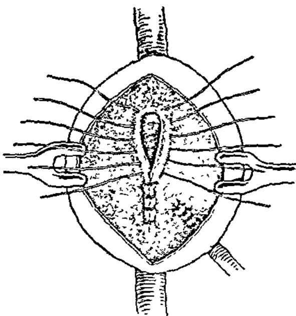


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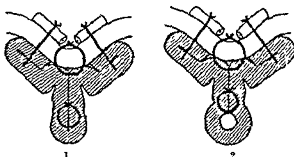


Fig. 642.—Obliterative (1) and non-obliterative (2) endo-aneurysmorrhaphy.

(*After Matas.*)

of clot, and the orifice or orifices sought. The defect in the arterial wall may be single, or there may be two orifices more or less widely separated and quite distinct, or connected by a groove in the floor of the sac, or there may be several lesser openings in addition.

If the orifice be single, or dual with intervening gutter, it may be possible so to suture it as to restore the lumen of the trunk (*restorative or reconstructive endo-aneurysmorrhaphy*). In most cases, however, all the orifices are closed (*obliterative endo-aneurysmorrhaphy*) by sutures of catgut inserted so as to hold the same relation to the intima that Lembert sutures have to the peritoneum; they may be interrupted or continuous: in either case the cavity is then obliterated by successive rows of similar sutures, plicating the walls; the sac is not removed.

In certain situations—for example, the common carotid trunk—and in circumstances where the probability of establishing an efficient collateral circulation is doubtful, it may be advisable, instead of ligating the trunk, to constrict it by malleable bands such as those of Halsted, which can either be tightened in successive stages until obliteration is attained, or, having been gently applied to the point of obliteration in the first place, can be removed within twelve hours without permanent interruption of the stream.

The choice of method is dependent on many considerations, referable for the most part to the individual case.

Ligature does not give any security from recurrence, and leaves the tumour to exert or aggravate existing pressure effects, and to initiate fresh ones, since in contracting, as clot organizes, the walls may kink or distort or compress nerves and vessels. Ligature may fail unless it can be so applied as to cut off enough collateral supply to the sac; or, if that be effected, gangrene may result. Gangrene is, in fact, more frequent after simple ligature than after extirpation, notwithstanding that extirpation of course implies ligations—partly because, unless immediately adjacent to the sac, it introduces a longer extent or an additional site of obliteration, and involves more branches, and also because the clot in the sac and parent vessel is a source of emboli which may be washed out by a returning collateral stream, or be accidentally pressed or shaken out into the trunk below and obliterate it itself again below, at a bifurcation, or at one of its branches.

The advantages of extirpation, which in Monod and Vanverts' statistics gives 90 per cent. of cures, 1·5 per cent. of failures, 4·5 per cent. of gangrenes, and 3 per cent. of deaths, are that cure is permanent, and all relievable pressure effects are eradicated. In the past the difficulties of the operation, and the danger of injuring important structures compressed by or enveloped in the walls, have

discouraged its use; but the statistical records, for what they are worth, do not bear out, in any way, the objections to the method.

Incision has the drawback that the sac is left, and there is a large cavity to granulate.

Matas's methods in his own and other hands have given very satisfactory results, but are applicable with greatest success in those cases which lend themselves most appropriately to extirpation, and do not to the same extent abolish existing or threatening pressure phenomena.

Re-establishment of the circulation through the trunk affected, when it can be accomplished, is eminently desirable, but it is only advisable when the artery is certainly not extensively diseased, or when trauma can be definitely alleged in causation. Even when it is re-established, circulation in the main trunk is not necessarily permanent.

It is to the advantage of Matas's method that, beyond the necessary exposure of one face of the sac, no extensive disturbance of the embracing tissues is necessitated.

ARTERIO-VENOUS ANEURYSMS

This term comprises the two allied conditions in which an artery and a vein communicate. In one there is a simple fistulous opening (*aneurysmal varix*); in the other blood passes from one channel to the other via a definite aneurysmal sac (*varicose aneurysm*). Practically all cases are of traumatic origin; the vast majority of arterio-venous communications of pathological origin are, in fact, secondary ruptures of arterial aneurysms into veins, and nearly all affect the aorta and great veins.

Formerly most cases were due to stab wounds or therapeutic bleeding, but of late years the collected cases have come from military sources, so that whilst von Bramann's 144 cases included 108 due to stabs, Monod and Vanverts found 71 out of 122 due to bullets; and the statistics of the late war relate almost exclusively to those caused by projectiles. Callander's 447 cases of all kinds give 189 due to projectiles (of which 166 were due to bullets), 161 to knife wounds, and 28 to contusions. Simultaneous injury of artery and vein by a fragment of bone, or erosion in an abscess or at the point of combined ligature in a septic amputation stump, and similar conditions are occasional causes. A few congenital cases are recorded.

Of 272 traumatic aneurysms 100 were of the arterio-venous type and 52 aneurysmal varix.

It was usually stated that the wound made by a small-bore high-velocity bullet gave the most favourable conditions for the formation of the communication—a small orifice, a relatively long track, and

simultaneous damage to artery and vein—but in the recent war Makins observed that arterio-venous lesions increased in proportional frequency with the advent of a greater number of injuries caused by fragments of shells. All arterio-venous communications result from lateral wounds or traversing perforations. If the vessels are in close proximity, parallel and more or less bound together, an aneurysmal varix or simple fistulous communication may result; much more often an arterial hæmatoma forms, and is contained by sheath or other resisting structures, or excites peripheral connective-tissue hyperplasia enough to form a definite wall; the cavity within the mural clot, being in contact with circulating blood, becomes epithelialized from the intima of the vessel, and a true arterio-venous aneurysm results. The lining of the aneurysmal sac is derived exclusively from the artery, with the wound in which it is directly connected. Nevertheless, the bulk of

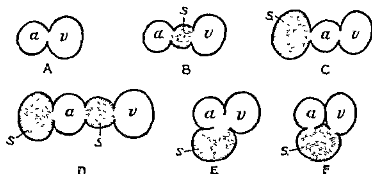


Fig. 643.—Arterio-venous aneurysms.

A, Simple aneurysmal varix B, Arterio-venous aneurysm: sac interposed C, Arterial aneurysm combined with aneurysmal varix D, Arterial and arterio-venous sac E, Arterio-venous sac with common opening of communication with artery and vein F, Arterio-venous sac with separate openings of communication with artery and vein. s, Sac

(*From Makins's "Gunshot Injuries to the Blood-Vessels"*)

the "tumour" may be due to dilatation of the vein. The sac is never found on the "free" side of the vein; the wound on that aspect always cicatrizes. (Fig. 643.) There are very often several smaller but important vessels in communication with the sac, both arteries and veins.

The artery above the point of communication is dilated and tortuous; below, it may be in a similar condition, but is generally smaller than normal. The muscular tissue atrophies, the elastic deteriorates. The vein both above and below is also tortuous, but its walls are hypertrophied—"arterialized," in fact. The venous dilatation is rapid or slow according to the size of the communication, and the valves stay the course of the dilatation but little; the phlebectasis may extend even to the heart. The blood-pressure in the vein varies from 50 to 90 mm.

Signs and symptoms.—Whilst aneurysmal varix is generally an immediate development, in the case of arterio-venous aneurysm there is often nothing at the time of the accident to indicate simultaneous injury of vessels; there may or may not be a pulsatile hæmatoma. Sometimes evidence is forthcoming within a few hours; sometimes it is a question of days or weeks. This may be due to pressure exerted by the primary hæmatoma or to temporary blocking of the openings by a thrombus.

The outstanding sign is a bruit and thrill of peculiar quality, continuous at the site of the lesion, but with systolic reinforcements, the continuous element gives place to the rhythmic at a distance in the course of the vein, or upon elevation of the part, if a limb; bruit and thrill both disappear upon compression of the main artery above The murmur is loudest and of highest pitch over the site of the communication. At onset the systolic element of the bruit may alone be audible, and it is accompanied by a very excitable state of the heart. The pulse-rate gradually steadies down, but may remain abnormally high for a time even after operative cure.

There may be a pulsatile, compressible tumour. The peripheral parts sometimes exhibit a chronic œdema, with verrucose changes in the skin, or indications that the circulation is imperfect both as to arterial supply and venous return; the surface temperature locally may be either lower or higher than normal. Cases at the base of the skull, or actually intracranial, give rise to troublesome subjective symptoms.

At the time of the accident there is seldom anything to indicate the simultaneous injury of artery and vein. The bruit and thrill are the most characteristic sign, but attention is sometimes first drawn to the development of a pulsatile dilatation of the veins; the proximal arterial pulse is of higher, the distal of lower, tension than normal. Remote effects on the circulation lead occasionally to gangrene and, on the cardiac side, to syncope.

Differential diagnosis of the two forms is possible by palpation when the vessels affected are superficial, and may be possible by radiographic observation if they are deeply situated. Certain forms of arterio-venous angioma present similarities clinically, the thrill is, however, not of the same purring or buzzing quality, and is not completely controlled by compression at one spot or of one trunk.

Treatment.—The fistulous form is generally of benign course; it may even undergo spontaneous cure. The aneurysmal type is always associated with some functional changes, and, though offering no particular menace, perhaps for years, is always a source of possible danger; it may terminate in rupture, but spontaneous gangrene is rare. Treatment, therefore, is seldom required, except for the aneurysmal type; but when pain, or increasing local dilatation of

the veins, or signs of peripheral venous obstruction call for operation in the fistulous type, the vein should be opened opposite the communication, and the wound in the artery should be sutured from that aspect, with subsequent suture of the incision in the vein. Failing this method, quadruple ligature with excision of the varix may be employed. In the aneurysmal type, ligature at a distance from the aneurysm is very dangerous; the only site for which it may be considered is in the case of communication between the internal carotid and cavernous sinus Quadruple ligature alone, that is of the artery and vein above and below, is too often followed by gangrene to be advisable, and, if employed, great care must be taken to secure all accessory communications. Excision of the sac should always be carried out in addition, if possible. Where it is possible to suture the lateral orifices, or to excise the affected part and reunite the ends of the vessels, removing the sac at the same time, the nearest approach to a *restitutio ad integrum* is attained. After the application of four provisional ligatures the opening in the arterial wall is approached either through the vein or through the sac, and often can be thus directly sutured. It is not advisable to rely for closure of the arterial wound upon flaps cut from the walls of the sac.

SPECIAL ANEURYSMS

Aorta.—Saccular aneurysms of the thoracic aorta have been treated by needling, the insertion of wire, and in America latterly by the Moore-Corradi method; a very few "cures" and some palliative successes are recorded. For saccular aneurysms of the ascending aorta and first part of the arch, not associated with valvular lesion or with obvious pressure on trachea or bronchi, distal ligature has given encouraging results; simultaneous ligation of the right subclavian and common carotid, ligature of the corresponding vessels of the left side, successive ligature of two or three trunks, have all been employed with some measure of success.

Aneurysms of the abdominal aorta are very much less frequent than those of the thoracic, and many cases of apparently leaking abdominal aneurysms are found to be really thoracic aneurysms from which the blood escapes through the diaphragm at the arcuate ligaments. Males are more liable than females in the proportion of 10 to 1. The branches, with the exception of the cœliac axis, which may be involved in those at its origin in the main trunk, are rarely affected. The course is usually fairly rapid, lasting about a year from first recognition; termination is by rupture, which may be into the peritoneum or even into the pleura, but is more often the cause of a diffuse retroperitoneal hæmatoma, that may pulsate for a time and is a source of many mistaken diagnoses.

Ligature of the aorta has been invariably fatal; it is possible that obliteration of the aorta below the origin of the renals may be feasible by means of Halsted's bands or some similar device for gradual constriction. Wiring, and some form of intrasaccular attack, are the only means available at the moment, and the results have not been very promising

Innominate.—Aneurysms of the innominate artery may be considered together with those of the proximal parts of the two main divi-

sions. It is rare for an aneurysm to occupy the innominate trunk alone; either the arch on the one hand or the primary branches on the other are involved.

Generally saccular, these tumours may attain a large size, sending pouches in every direction and rising above the clavicle, the innominate in the episternal notch, the common carotid between the heads of the sterno-mastoid, the subclavian behind the outer part of the clavicular head of that muscle. The sternum may be eroded and perforated, the clavicle dislocated; the trachea displaced and compressed, the œsophagus pressed upon; the vagus and recurrent laryngeal, the phrenic and sympathetic nerves, and the trunks of the brachial plexus are flattened. Rupture may take place externally or into the trachea, bronchi, or œsophagus. Besides diminishing the volume of the pulse in the branches of distribution, these aneurysms occasion a retardation in the whole area, recognizable by the sphygmograph on comparison with the opposite side.

The operation of choice is simultaneous ligature of the common carotid and subclavian arteries; successive ligation is inferior, but may be used when, for example, the subclavian is already compressed by the tumour. In any case, it is important to ascertain patency of the left carotid trunk before ligaturing the right. Cerebral softening and embolism are still serious dangers, although asepsis minimizes the latter risk.

Common carotid.—Excluding those at the origin of the trunk, most aneurysms arise close to the bifurcation, and here are not much less frequent on the left side than on the right. Women are relatively more susceptible in this situation than elsewhere; they suffer in about the proportion of 3 to 5. The size is not usually very great, but pressure is exerted on the 9th, 10th, 11th, and 12th nerves besides the laryngeal and trunks of the cervical and brachial plexuses, with the attendant symptoms; the trachea may be compressed. There may be pains and noises in the head, faintings and vertigo, hemiplegia, and terminal coma.

Pulsation may be absent, either on account of the thickness of the walls or the amount of clot; when suppuration occurs, diagnosis may be difficult, especially in the presence of inflamed glands; malignant glands and some forms of vascular goitre have given rise to difficulty in recognition.

Cerebral accidents after ligation are much less frequent than formerly, but the arteries should be sound—a condition usual in the saccular forms which arise from syphilis, local arteritis, or trauma. Proximal ligature, alone, invites embolism by exposing clot to the stream returning down the external carotid to reach the internal, or vice versa. The danger of inadequate cerebral supply can be met by the use of Halsted's bands. Latterly, extirpation has been growing in favour as the operation of choice; intrasaccular obliteration, proximal and distal ligature, with and without incision of the sac, have all had some success. The statistics of "cure" are depressing.

Subclavian.—Aneurysms of the first part on the right side are considered with those of the innominate; on the left side they are extremely rare. Those of the second part run into those of the third, and these likewise into those of the first part of the axillary. Men are much more liable than women, and the right side is twice as often affected as the left—both facts worth consideration in connexion with the frequency of antecedent strain, sudden or severe, to the right arm. Usually small and saccular, they may be very big, sending pouches out under the scapula, into the axilla, and high into the neck; they eventually rupture externally or into the pleura, trachea, or a bronchus. They occasion dilatation of super-

the veins, or signs of peripheral venous obstruction call for operation in the fistulous type, the vein should be opened opposite the communication, and the wound in the artery should be sutured from that aspect, with subsequent suture of the incision in the vein. Failing this method, quadruple ligature with excision of the varix may be employed. In the aneurysmal type, ligature at a distance from the aneurysm is very dangerous; the only site for which it may be considered is in the case of communication between the internal carotid and cavernous sinus Quadruple ligature alone, that is of the artery and vein above and below, is too often followed by gangrene to be advisable, and, if employed, great care must be taken to secure all accessory communications. Excision of the sac should always be carried out in addition, if possible. Where it is possible to suture the lateral orifices, or to excise the affected part and reunite the ends of the vessels, removing the sac at the same time, the nearest approach to a *restitutio ad integrum* is attained. After the application of four provisional ligatures the opening in the arterial wall is approached either through the vein or through the sac, and often can be thus directly sutured. It is not advisable to rely for closure of the arterial wound upon flaps cut from the walls of the sac

SPECIAL ANEURYSMS

Aorta.—Saccular aneurysms of the thoracic aorta have been treated by needling, the insertion of wire, and in America latterly by the Moore-Corradi method; a very few "cures" and some palliative successes are recorded For saccular aneurysms of the ascending aorta and first part of the arch, not associated with valvular lesion or with obvious pressure on trachea or bronchi, distal ligature has given encouraging results; simultaneous ligation of the right subclavian and common carotid, ligature of the corresponding vessels of the left side, successive ligature of two or three trunks, have all been employed with some measure of success.

Aneurysms of the abdominal aorta are very much less frequent than those of the thoracic, and many cases of apparently leaking abdominal aneurysms are found to be really thoracic aneurysms from which the blood escapes through the diaphragm at the arcuate ligaments. Males are more liable than females in the proportion of 10 to 1. The branches, with the exception of the cœliac axis, which may be involved in those at its origin in the main trunk, are rarely affected. The course is usually fairly rapid, lasting about a year from first recognition; termination is by rupture, which may be into the peritoneum or even into the pleura, but is more often the cause of a diffuse retroperitoneal hæmatoma, that may pulsate for a time and is a source of many mistaken diagnoses

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ficial veins, œdema of the arm, neuralgia, and pareses or actual paralysis of the arm.

For spontaneous aneurysms the treatment of choice is extirpation; for the traumatic ones, which form 15 per cent. (Matas), incision gives the best results Ligature of the innominate, with or without ligation of the carotid or vertebral, has given better results of late years than formerly. Obliterative aneurysmorrhaphy (p. 142) may be employed, but the retention of the sac when there is extant pressure on many nerve-trunks is undesirable.

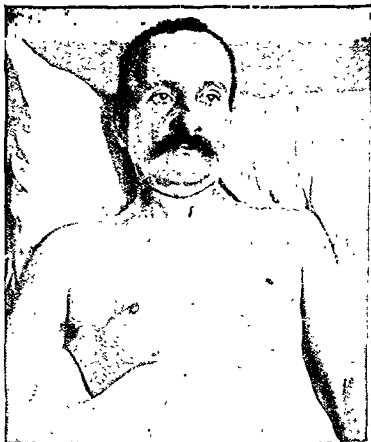
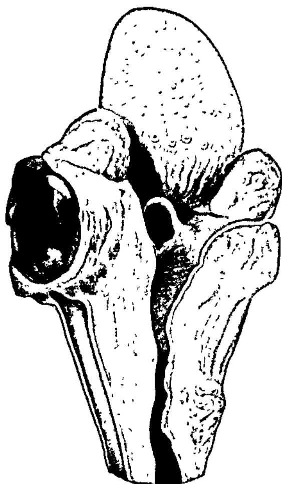


Fig. 644 —Aneurysm of second part of right axillary artery; the patient had also a large aortic aneurysm.

Axilla.—Aneurysms here include those of the second part of the axillary (Fig. 644), of the commencement of the brachial, and of the subscapular and circumflex branches. Bullet and stab wounds, falls, dislocations, and the reduction of old-standing displacements of the humerus account for a good many cases; even the continued friction of crutches has been held responsible for initiation of an aneurysm. Women are very seldom affected. Growth is rapid, and the size attained may be great; ribs and the clavicle may be eroded; extension takes place up under the pectorals, more rarely down the arm. Rupture may occur into the pleura or superficially. These aneurysms are always painful; and frequently accompanied by palsy and œdema.



Aneurysm, probably traumatic, of a tonsillar branch of the internal carotid; rupture into the pharynx; death from hæmorrhage.

The patient was a girl aged 3 An abscess in the left tonsil was opened four weeks before death

(*Westminster Hospital Museum.*)

Aneurysm here may be confused with a sarcoma of the humerus or of the brachial plexus; or, when inflamed, with an abscess.

Direct methods of treatment give much better results than ligature. Incision in some hands has yielded very good results; extirpation, when possible, is desirable because of the pressure phenomena, but may endanger structures involved in the walls. Purely traumatic forms should be incised and the wound in the artery sutured; Matas's method (p. 141) gives good results. Whilst ligature gives a high percentage of gangrenes, Monod and Vanwerts in their 14 collected cases of direct attack found none.

Internal carotid.—Intracranial aneurysms are many of them traumatic, and often arterio-venous; if of the latter form, they are accompanied by pulsating exophthalmos. Ptosis, strabismus, vertigo, and headache are common; the thrill and bruit are perceived by the patient, and occasion great suffering.

Extracranial forms may be proximal, when they resemble in their clinical characters those of the distal part of the common trunk—and, indeed, the bifurcation is often involved in the aneurysm—or distal, when they encroach on the pharynx, pushing in the posterior pillar of the fauces, the tonsil, and eventually the anterior pillar. Their termination is usually by rupture. (Plate 108.) When inflamed, or devoid of pulsation, they are not infrequently mistaken for tumours or abscesses, and have been incised under that misapprehension, sometimes with success.

It may be possible to ligature the internal trunk proximally, but usually it is better to ligate the common and external carotids. Extirpation is practically out of the question, and Matas's method is rarely applicable.

External carotid.—Aneurysms of this trunk are not quite so common as those of the internal, but more occur on the branches. They are generally easily reached, and should be extirpated if possible, but ligation of the common trunk gives 50 per cent. of cures. For temporo-maxillary forms Dawbarn has used paraffin injection with success.

Iliac.—Aneurysms of the common iliac trunk and of the internal branch are rare; those of the external trunk are more common. Being unsupported towards the peritoneal aspect, they usually run a rapid course. In many there is a history of trauma, direct or indirect, such as some great muscular effort. The symptoms are unfortunately delayed; pains in the anterior or genito-crural areas may be occasioned; there may be no recognizable pulsation, and yet the aneurysm may grow; suppuration may occur and the tumour may be opened as an abscess. The usual age is from the twentieth to the fortieth year. Varices and œdema of the limb may be present late. Psoas contraction, erosion of the pelvis, and extension into the hip-joint occur. Ligature of the external iliac is often impossible; ligation of the common femoral is inefficient, and very often followed by gangrene; obliteration or excision gives better results.

Inguinal aneurysms—that is, those of the common femoral trunk and the commencement of the superficial and profunda branches—occur, as a rule, in middle life, from 25 to 40. Trauma, in the shape of blows, wounds, strains, dislocations, plays some part in causation; a very few arise from erosion. They may involve the terminal part of the external iliac or extend up under Poupart's ligament; a thrill is then perhaps to be felt. They sometimes occasion marked œdema, pains of crural distribution, and limitation of movement. Gangrene is not uncommon, and inflammation with consequent external rupture is not rare. If the bruit and pulsation

be absent it is easy to mistake these swellings for a hernia, enlarged glands, a solid tumour, or an abscess.

Ligature of the common femoral, even when possible, involves too great a risk of gangrene; ligature of the external iliac is less dangerous, but incision, extirpation, or intrasaccular operations will be found to give the best results.

Femoral aneurysms give rise to but few symptoms; they are less frequent than popliteal in the proportion of about 1 to 4; a good many are traumatic, but this trunk is the most common site for the multiple aneurysms which probably derive from an inherited deficiency of the middle coat. They are treated nowadays either by extirpation or by endo-aneurysmorrhaphy.

Popliteal aneurysms constitute about one-third of all peripheral aneurysms. The reason for the frequency with which this part of the vascular tract is affected is not easy to ascertain; the artery is subject to many stresses, and possibly to minute repeated traumata of the media or intima, occasioned either directly or through a locally raised blood-pressure. Both popliteal arteries are sometimes affected; usually only a small area of the otherwise healthy vessel is involved. The aneurysm may be in the upper part of the vessel, and even extend through the opening in the adductor magnus; or it may be low down between the heads of the gastrocnemii, and in the latter situation is much more dangerous, because the veins are more liable to be compressed; spontaneous gangrene is then not infrequent.

Males are almost exclusively affected, but direct trauma plays a very minor part in the production of this aneurysm. The "tumour" may develop on either the anterior or posterior aspect of the vessel, or the trunk may alter its relation to the sac as the latter rotates during enlargement in the confined space. Extension into the joint is rare; the lymphatic glands of the space are often enlarged.

The symptoms are at first but slight—some limitation of movement, particularly of extension, some discomfort in the joint, a little œdema, minor paræsthesiæ, cramps, or pareses. Later, pain and trophic disturbances are produced. Local necrosis results from lodgment of small emboli, extensive gangrene from blockage of the tibial branches.

Diagnosis is required from vascular sarcoma, from certain cysts, and from cold abscesses.

If untreated, popliteal aneurysm almost invariably ends in either gangrene or rupture. The classical method of treatment has been proximal ligature at a distance; if it is used now the ligature is applied as close to the sac as possible. But extirpation is rapidly gaining favour; when possible, it is sometimes accompanied by reunion of the artery, and even the engrafting of a vein between widely separated ends of the artery has been accomplished with success. Matas's methods have here found their most frequent exposition, with many remarkable successes. Here, as elsewhere, the obliterative method is open to the objection that the sac is left, and that pressure phenomena are not directly relieved. Every method but extirpation is open to the objection that, even after consolidation or "cure," pressure effects may be unrelieved or even appear for the first time.

Gluteal and **sciatic** aneurysms, when entirely extrapelvic, are to be excised if possible; if purely or partly intrapelvic, they should be treated by ligature of the internal iliac.

Aneurysms **below the knee and elbow** are to be excised.

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NOTE.—The alterations and additions in the section dealing with the vessels, in this edition, are almost wholly derived from Sir George Makins's *Gunshot Injuries to the Blood-Vessels*, to which the writer wishes to acknowledge his indebtedness.

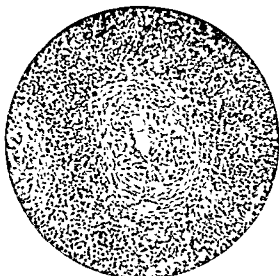


Fig. 1.—Acute tuberculosis of a lymphatic gland

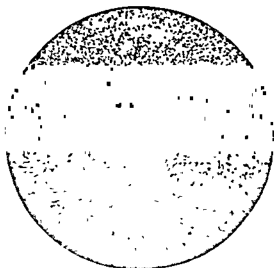


Fig 2.—Caseating lymphatic gland

PLATE 109

TUBERCULOUS LYMPHADENITIS

Etiology.—Tuberculous disease of lymphatic glands is more often met with in childhood than in later life, though it may occur at any age. There is no evidence that it is hereditary, but the children of tuberculous parents are more likely to contract tuberculous adenitis than those of healthy people.

The tubercle bacillus can be stained and found in sections of tuberculous glands, and tuberculosis can be produced in animals by inoculation of gland tissue. The bacilli are not, as a rule, so numerous in the tubercles found in glands as they are in those in the lungs and other organs; their discovery in sections may necessitate a very prolonged search, yet inoculation of part of the suspected gland will reproduce the disease.

Tubercle bacilli of the bovine type as well as of the human type have been isolated from diseased glands.

It has been suggested that one type may, after the lapse of time, assume the characteristics of the other type, and that individuals infected during infancy with the bovine bacillus may in later years show lesions containing bacilli of the human type. It is probable that in the majority of cases of tuberculous cervical adenitis in young children the infection is derived from tuberculous milk, while in older children and in adults it is caused by the inhalation of dust containing bacilli from dried sputum. In mesenteric gland disease the bovine type of bacillus is the one usually found, and the consumption of tuberculous milk is responsible. In tracheo-bronchial gland disease the infection may arise by inhalation of dust containing bacilli, or the disease may be secondary to primary abdominal-gland tuberculosis following the ingestion of tuberculous milk.

Pathology.—Tuberculous changes in the lymphatic glands resemble those in other tissues (*see* Vol. I., p. 757) Tubercles are formed (Plate 109, Fig. 1), and caseation and suppuration take place in the usual way. Resolution may occur, or the disease may spread to surrounding structures The severity of the morbid processes varies with the age and resisting power of the patient, the virulence of the infecting organism, and the presence or absence of a superimposed pyogenetic infection. In very young children caseation and suppuration are apt to occur early, and in some cases the disease spreads rapidly from one gland group to another, quickly giving rise to suppuration. In the very earliest stages an affected gland may be simply enlarged, with no tubercles, macroscopic or microscopic; or section of the gland will show tubercles as opaque white or yellow dots projecting a little above the surface. In more advanced cases caseous areas will be found throughout the gland substance, or the whole of the gland tissue may be replaced by caseous material (Plate

109, Fig. 2). Periadenitis with thickening of the gland capsule is a later manifestation, and in this way the neighbouring glands become adherent to one another. The lymph-vessels running from gland to gland also show evidences of the disease. When suppuration occurs, cavities will be found containing tuberculous pus and lined with breaking-down tubercles, not only in the gland itself, but also frequently in the periglandular tissue. These abscesses increase in size, destroy overlying fascia, muscle, and skin, and discharge on to the surface or into an internal cavity such as the peritoneum, or into a viscus as a bronchus. The sinus which remains after the rupture of a glandular abscess may heal, or may continue to discharge for a very long period, and in some cases it becomes infected with pyogenetic organisms. Rupture of a suppurating gland may set up a diffuse tuberculous cellulitis which ends in extensive involvement of the skin and the formation of numerous sinuses.

The disease may end before suppuration takes place; in the earliest stages the tubercles may be destroyed, leaving little or no traces of their presence. At a more advanced stage the progress of the affection may be terminated by a diffuse fibrotic change in the gland. Caseous areas become encapsuled and their contents calcify; these hard cretaceous masses persist throughout life, and may give rise to suppuration many years later. A caseous gland, surrounded by a thick fibrous capsule, may persist as a form of cyst; these are sometimes met with in the mesentery, and have been mistaken for dermoid cysts. Healing frequently occurs after long-continued suppuration, ugly, puckered, depressed scars resulting. At any stage in the development of tuberculous glands the disease may manifest itself in other parts of the body—in the bones, joints, peritoneum, internal organs, etc.; or life may be terminated by tuberculous meningitis or general tuberculosis.

It has been held by some that the occurrence of tuberculous adenitis during childhood confers some immunity against tuberculous disease in later life. There is little to support this view, and much against it. True, one frequently sees individuals in vigorous health who have suffered from extensive tuberculous adenitis during childhood, but it is certain that visceral and other tuberculous affections in the adult not infrequently have their origin in an unhealed glandular focus.

Cervical Adenitis

Cervical tuberculosis is more prevalent than the glandular disease elsewhere, and is frequently the first manifestation in the individual. The bacilli may pass through mucous membranes into the lymphatics without any actual lesion at the point of entry; enlarged tonsils and naso-pharyngeal adenoid vegetations are, however, frequently present

and often harbour the micro-organisms (Fig. 645). When the bacilli enter by this route the anterior group of the upper deep cervical glands is first affected. Carious teeth are frequently the cause of a tuberculous adenitis, and the bacilli have been detected in the cavities of the teeth and in the pus of an alveolar abscess; the submaxillary glands are then the first attacked. Other predisposing conditions



Fig. 645.—Tuberculous cervical glands associated with enlarged tonsils and with adenoids.

are eczema and impetigo of the scalp (Fig. 646), ears, lips, face, etc., pediculi, cracks and fissures of the lips, and middle-ear disease. Not infrequently glandular disease is a sequel of scarlet fever or measles, or of an acute or chronic adenitis.

Secondary tuberculous adenitis may be associated with tuberculous ulceration of the tongue, lips, pharynx, larynx, nose, etc., or with tuberculous middle-ear disease. In these cases the gland disease is not usually extensive, and is of less importance than the

primary affection. Tuberculous adenitis is sometimes, though rarely, secondary to lupus of the face.

The lower deep cervical glands may become enlarged during the course of tuberculosis of the lung or as a result of disease in the tracheo-bronchial glands. The path by which the infection spreads in these cases is imperfectly understood, but its occurrence is recognized as a symptom of great gravity. The same group may be affected as a sequel to abdominal tuberculosis, the infection being conveyed by the thoracic duct.



Fig. 646.—Tuberculous cervical glands infected from scalp.

Note the progressive invasion of the mastoid glands and the posterior glands of the upper and lower deep cervical group.

Symptoms and course.—At first, cervical tuberculous adenitis is unattended by any deterioration of the general health. There are no local symptoms, the indolent, painless, slow enlargement of the glands attracting attention only by the increase in size. Later, as caseation occurs, some malaise, with perhaps an evening rise of temperature and a little diminution in strength and energy, becomes obvious. When softening and suppuration occur, local symptoms are noticed—a little pain and tenderness, stiffness of the head and neck, and disinclination to wear a collar. As the abscess enlarges, the skin becomes red and discoloured, and pain and tenderness increase until the abscess bursts. When a pyogenetic infection is super-

imposed the symptoms are more acute, resembling those of an acute lymphadenitis, and may call for the immediate relief of tension by an incision. The general condition of the patient suffers, and sometimes there is marked pyrexia with wasting and loss of appetite and strength. The disease spreads slowly from one gland group to another and may become bilateral, though it is more advanced on one side than the other. It may rapidly involve group after group of glands, and eventually terminate in general tuberculosis or tuberculous meningitis. Involvement of the lower deep cervical glands is not infrequently followed by the appearance of enlarged glands in the axilla, the result apparently of a retrograde infection along the lymph-vessels In some cases symptoms of tracheo-bronchial gland disease, in others signs of pulmonary disease, may become apparent.

Differential diagnosis. 1. Acute adenitis.—The presence of a primary lesion, the acute onset, severity of the inflammatory reaction, the rapid course of the affection either towards recovery or to suppuration, make the diagnosis in most of these cases a matter of little difficulty. It must be remembered, however, that tuberculous adenitis sometimes runs a rapid course towards suppuration, and that the infection of tuberculous glands by pyogenetic organisms can produce most acute symptoms. Inquiry should be made as to the presence of enlarged glands before the acute symptoms manifested themselves.

2. Chronic simple adenitis.—Most cases of so-called chronic adenitis are in reality examples of tuberculous gland disease. It is true that a chronic, symptomless enlargement of lymphatic glands may be associated with the presence of carious teeth or enlarged tonsils and adenoids or other chronic infection, and may disappear on the removal of the cause. When prompt subsidence of such an enlargement does not occur it should be regarded and treated as tuberculous

3. Hodgkin's disease.—The diagnosis from this condition is usually easy. The occurrence of periadenitis fixing the glands together, and of softening and suppuration when the mass reaches any size, which are characteristic of most forms of tuberculous adenitis, serves to distinguish the two affections. It is true that in some cases of tuberculosis (Fig 647) the glands remain loose and movable, and attain a considerable size before softening is noted, and these cases may give rise to difficulty, but microscopical examination will usually enable a positive diagnosis to be given, though it should always be remembered that lymphadenomatous glands may become infected with *B. tuberculosis.*

4. Lympho-sarcoma or other form of malignant disease in glands can usually be readily distinguished by the intense hardness, early

and extensive fixation, the presence perhaps of a primary growth, and the rapid course.

Treatment.—The patient's habits and environment must be regulated to prevent further tuberculous infection and to increase, if possible, his resistance to the disease. Purity of a child's milk supply must be secured, by sterilization if necessary. Whenever practicable, the patient should be protected from contact with any

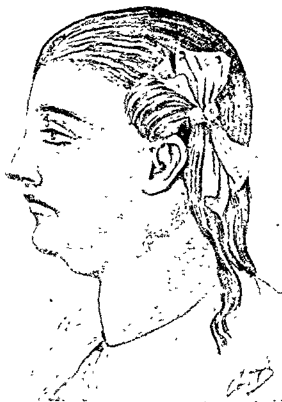


Fig. 647.—Pseudo-lymphadenomatous lymphatic tuberculosis.

phthisical person. When the home conditions do not permit of adequate air-space, particularly at night, of efficient ventilation, of clean, dustless rooms, of sufficient warm clothing and simple food, he should, if possible, be removed for institutional treatment. Fresh air and sunlight are as important in the treatment of glandular as of other forms of tuberculosis, and much good may be done by a prolonged stay at a bracing seaside resort or in a dry moorland country. Attention must be given to any abnormal local conditions predisposing to the glandular infection. Carious teeth must be extracted or stopped, and enlarged tonsils and adenoids removed;

enucleation of the tonsil is to be preferred to amputation with the guillotine, as the tonsil is known to contain tubercle bacilli in some cases, and its complete removal is desirable. Eczema, impetigo, pediculosis capitis, middle-ear disease, etc, must receive appropriate treatment. Cod-liver oil appears to be of benefit, but drugs are not of much avail, and the local applications so commonly used are of doubtful value.

Treatment on these lines will very frequently result in complete disappearance of the enlarged glands, and in most cases there will be no further manifestations of the infection.

The injection of tuberculin has been very extensively employed, but a more extended experience has convinced the writer that improvement can rarely be attributed to its administration

Aspiration of abscesses and injection with emulsion of iodoform and glycerine, solutions of iodine, etc., is a method of treatment which has deservedly fallen into disuse. Subsequent operative treatment is almost invariably necessary.

X-rays and radium.—At the present time it is almost impossible to obtain sufficient reliable evidence of the value of treatment either by X-rays or by radium. True, Tichy found that while, of 79 cases treated by operation, recurrence took place in 74 per cent., of 27 cases treated by X-rays only 11 per cent. recurred; treatment by radium has been reported by other observers to be equally successful (Molyneux). But, according to Dowd, 91 per cent. of cases treated at a reasonably early stage by a sufficiently complete operation were permanently cured.

One has suspected that in some cases suppuration has been hastened by irradiation; and when excision of glands is necessary after ray treatment, the firm periglandular fibrosis which is commonly encountered renders the operation extremely difficult.

Operative treatment.—Excision of tuberculous glands of the neck is an operation which, as Stiles has said, "is performed too seldom rather than too frequently, and which, moreover, is often too long postponed" To obtain the best results, with rapidity of healing, absence of a prominent scar, and freedom from recurrence, the operation should be done before suppuration has occurred. It is to be advised when more simple measures, including the treatment of any predisposing affection of the mouth or throat, have been tried and have failed to induce repair in the diseased glands, when the affection spreads rather quickly from one gland group to another, or when there is reason to fear suppuration. When abscesses or sinuses have formed, operative treatment is essential. The range of the operation to be performed will depend on the extent of the enlargement and on the presence or absence of an abscess or a sinus.

troublesome, but should be avoided if the position of the vein is remembered.

The entry of air into a vein is most likely to take place in the dissection at the root of the neck: when the accident occurs a peculiar hissing noise will be noticed, and the patient may immediately collapse, the pulse fail, the pupils dilate, the face become pale; and when a large quantity of air has entered, death may be almost immediate. On listening to the heart a peculiar churning noise will be heard. In the slighter cases the air contained in the heart is driven forwards into the capillaries of the lung, and the patient recovers quickly. The accident is to be avoided by sufficient exposure and by careful dissection; should it occur the wound should be filled at once with saline solution or sterile water, not with an antiseptic lotion, and the opening in the vein closed by the pressure of the fingers or gauze The wound is then dried and the aperture in the vein seized with forceps and subsequently ligatured. When the accident is dealt with promptly the patient quickly recovers. In the more severe cases intramuscular injections of ether or brandy are given and the foot of the table is elevated. If recovery does not occur, undoubtedly the most rational method of treatment would be to perform massage of the heart and attempt to squeeze the air onwards into the pulmonary vessels. This may be done through the diaphragm after making an abdominal incision, the heart being pressed against the chest wall by the hand inside the abdomen.

The nerves most likely to be injured are the spinal accessory, particularly in the posterior triangle, the facial and its inframandibular branch, and to a lesser degree the hypoglossal, the vagus, sympathetic, phrenic, muscular branches of the cervical plexus, and the cords of the brachial plexus. The facial trunk should not be in danger, but the inframandibular branch is not infrequently wounded in removing glands adherent to the parotid or in the submaxillary triangle. The lower lip is then partially paralysed, but this always recovers. The superficial branches of the cervical plexus are, of course, divided in making the skin incisions, but the resulting anæsthesia disappears in a short time.

When an abscess or sinus is present with a mass of enlarged glands it is the practice of some surgeons to perform excision at once, opening the abscess in the first incision, or perhaps after removing an ellipse of damaged skin, wiping away pus and caseous material, scraping the cavity, and then proceeding to remove the mass of glands. The objection to this procedure is the risk of producing a cellulitis of the neck or even of disseminating the disease It is better to deal with the abscess or sinus on the lines about to be indicated, and to perform excision later when the wound is almost or entirely healed.

When an abscess or sinus is present without extensive glandular enlargement the abscess should be opened or the sinus enlarged by a small oblique incision, caseous material and granulation tissue thoroughly scraped away (care being taken to remove any caseous glands lying beneath the fascia), the wound purified with hydrogen peroxide and drained. The patient should then be treated by the methods previously described, but if further glandular enlargement manifests itself excision must be performed without delay.

Tuberculous cervical adenitis secondary to tuberculous ulceration of the tongue, larynx, pharynx, etc, or to phthisis or tracheo-bronchial glandular disease, is overshadowed by the primary disease; its surgical treatment should be limited to opening abscesses as they form.

Tuberculosis of the Mediastinal and Tracheo-Bronchial Glands

Disease of these glands is very common, though rarely coming within the province of the surgeon. Suppuration is infrequent, but if an abscess forms in the mediastinum it will cause symptoms by pressing on the œsophagus, trachea, or bronchi. If an abscess can be recognized (for this a radiograph is almost indispensable), and appears to be within reach, an effort should be made to open and drain it by removing portions of the 2nd, 3rd, or 4th costal cartilages, and perhaps part of the border of the sternum, on whichever side the abscess appears more prominent. It may be necessary to tie the internal mammary artery, and the position of the large vessels and other structures must be borne in mind. No attempt should be made to scrape the abscess wall or to remove the glands; the cavity is merely opened and drained. Occasionally such an abscess will perforate the chest wall and simulate one arising from caries of the rib, on opening it an aperture will be found leading into the chest. This may be enlarged by removing a costal cartilage or part of the border of the sternum, and the intrathoracic cavity drained. In the after-treatment of such a case careful aseptic dressing is essential, and hygienic treatment on the lines indicated is of importance.

A mediastinal abscess may compress the œsophagus, and may eventually burst into it. If an abscess opens into the trachea or one of the bronchi it is likely to cause suffocation; a caseous gland has even found its way into the trachea and caused death in the same way. Such a case might perhaps be saved by tracheotomy.

Tuberculosis of the Mesenteric and Ileo-Colic Glands

These groups are very commonly affected during infancy by the consumption of tuberculous milk. The tendency to repair is great, and many children who have presented some signs of the disease—a tumid, rather tender abdomen, elevation of temperature, loss of appetite and weight, diarrhœa, etc—make a perfect recovery. In other cases the disease spreads to other organs, and death occurs from general tuberculosis or meningitis. In the majority of cases of abdominal lymph-gland tuberculosis in children the intestinal mucosa

is free from any tuberculous lesion. Glandular disease does, however, occur in cases of tuberculous ulceration of the bowel and in tuberculous disease of the appendix and cæcum. It is said that a chronic appendicitis, in children particularly, predisposes to infection of the glands of the ileo-colic chain by tuberculosis; certainly the two conditions are often associated, and the gland disease subsides after the appendix has been removed.

The complications of gland disease commonly bring these patients into the hands of the surgeon. A suppurating gland may rupture into the peritoneum and give rise to acute symptoms simulating perforative appendicitis. The diffusion of tuberculous material over the peritoneum may set up an acute tuberculous peritonitis, or a localized tuberculous abscess may form. An abscess will perhaps develop between the leaves of the mesentery, or, in the case of the ileo-colic glands, behind the posterior parietal peritoneum. Such an abscess is sometimes surrounded by a very thick fibrous wall, and forms a species of cyst which has been mistaken for a dermoid cyst until a microscopical examination is made. A loop of bowel frequently becomes adherent to a diseased gland, the resulting kinking causing attacks of colic which in the presence of a palpable mass of glands may simulate an intussusception. Acute intestinal obstruction may result from acute kinking of the bowel at the point of adhesion to the gland, or may be caused by adhesions or bands the result of a localized peritonitis. Calcification of the glands, the usual way in which the disease is terminated, sometimes gives rise to difficulties in the X-ray examination of cases, a shadow being thrown which may simulate a renal or ureteral calculus

Treatment.—Surgical procedures are comparatively rarely indicated in cases of abdominal lymph-gland tuberculosis, and reliance is to be placed mainly on general and hygienic measures and the removal of the source of the infection. When there is any reason to believe that the appendix is diseased it should be removed. When the mesenteric or ileo-colic glands are extensively affected, no attempt to extirpate any number of glands is to be contemplated. As may be seen in specimens prepared by injection of the lymphatics with Prussian blue, the relations of the glands to the blood-vessels are so intimate that any such procedure would imperil the vitality of the bowel. There are cases, however, where the disease is limited, perhaps, to one gland or to a small group of glands; in such cases diffusion of caseous material over the peritoneum, and a consequent tuberculous peritonitis, may be prevented by timely interference. The diseased gland or glands may form a mobile, slightly tender tumour unaccompanied by signs of free fluid or other symptoms of tuberculous peritonitis. It is occasionally possible to remove a diseased gland *in toto*,

but in most cases one must be content with excising portions of the gland capsule, scraping away all caseous material, purifying the cavity with peroxide of hydrogen, and obliterating it with catgut sutures. (Fig. 650) There can be little doubt that cases suitable for operative treatment on these lines are to be met with occasionally, and their early recognition and treatment may prevent the development of tuberculous peritonitis, particularly the "caseous" variety, in which



Fig. 650.—Mass of caseous glands in the mesentery, treated by partial excision.

the prognosis is so bad. An abscess arising from the ileo-colic glands or enclosed in the mesentery may form a palpable tumour, and should be dealt with on similar lines, no drainage being employed. In some cases an abscess is surrounded by a thick, fibrous wall, and forms a species of cyst which may, perhaps, be removed in its entirety.

The complications of the disease frequently demand surgical interference. When the bursting of a gland produces acute symptoms, appendicitis may be suspected, and unless there are signs of tuberculosis elsewhere an accurate diagnosis is difficult; it is likely that

the abdomen will be opened, and when the appendix has been examined the possibility of gland disease should be remembered, and *the mesenteric and ileo-colic glands investigated.* Any extravasated tuberculous material should be removed and the gland cavity treated as described above

In all cases of diffuse and localized tuberculous peritonitis and of *acute intestinal obstruction* dependent on tuberculosis general treatment is indicated after operation.

Tuberculosis of other groups of abdominal glands—cœliac, middle colic, inferior mesenteric, etc.—is usually secondary to diffuse glandular disease, and no special surgical treatment is indicated.

Tuberculosis of the Glands receiving Lymph from the Extremities

These glands may become affected in many different ways, as follows:

1. From local tuberculous lesions—tuberculosis of the breast affecting the axillary glands, tuberculous ulceration of the anus affecting the inguinal glands, tuberculous ulceration of the skin, etc. Glands rarely become diseased as a sequel to bone or joint tuberculosis.
2. From a wound infected with the tubercle bacillus This is a much more common event than is generally recognized. It is more often met with in the lower than in the upper extremity, as would be expected, and occurs particularly in children who run barefoot. A tuberculous ulcer of the skin may be seen in the situation of the wound or a pigmented scar with a history of long delay in healing.
3. By extension from a neighbouring group of glands
4. As part of a general affection of the lymphatic system.

Upper extremity.—The groups of glands which may become diseased are the axillary, the supracondylar, the brachial (a small group of glands lying along the brachial artery), and the small glands lying in association with the cephalic vein near its termination.

The **axillary glands** are the most frequently affected; suppuration occurs here as elsewhere, and the principles of *treatment* are identical with those adopted in the case of the cervical glands. *Excision* should be performed at an early date, before abscesses and sinuses form, particularly in those cases where there is a definite local lesion preceding the glandular disease. The glands can be readily removed through an *incision parallel to and a little behind the anterior fold* of the axilla, the pectoralis major is retracted, and the glands can then be dissected off the great vessels and nerves. When they are very adherent, or when sinuses are present, the operation may be *one of extreme difficulty and it may be necessary to divide some of* the fibres of the pectoralis major. Care must be taken not to inter-

fere with the nerve supply of the pectoral muscles, or with the nerve of Bell or the long subscapular nerve. When axillary-gland disease is associated with general glandular tuberculosis, operative treatment is of doubtful value. When sinuses are present they may be enlarged and curetted and drained, and they will sometimes heal; but, as a rule, excision of the glands becomes necessary. Tuberculous disease of the supracondylar and brachial glands and of the glands on the cephalic vein is best treated by excision.

Lower extremity.—The groups of glands likely to become affected are the inguinal glands, the glands in the iliac fossa, and the popliteal glands. Before the diagnosis of tuberculosis of the **inguinal glands** is established the various forms of venereal adenitis must be excluded. A careful search should be made over the whole of the lymphatic area for a local tuberculous lesion, an infected wound, or the scar of a recent wound. When the infection is derived from a lesion in the leg the inferior groups of the inguinal glands are, as a rule, the first affected. From these glands the infection spreads to the superior groups, and thence, perhaps, to the glands in the iliac fossa. When the disease is secondary to tuberculous ulceration about the anus the superior groups of the inguinal glands are attacked first.

Treatment.—Excision of the inguinal glands should be performed at an early stage before abscesses or sinuses form. A curved flap, with its base at Poupart's ligament, may be turned upwards, or the glands may be exposed by an incision parallel to and a little above the ligament, and another running downwards from it in the line of the femoral artery. The whole group of glands is then dissected off the deep fascia *en masse*. The superficial branches of the femoral artery will require ligature, and in many cases the saphenous vein also. The deep inguinal glands should be examined by opening the crural canal, and if diseased should be removed. When the iliac glands, lying to the outer side of the external iliac vessels, are affected, they may be removed by making a transverse incision through the abdominal muscles above Poupart's ligament; the peritoneum is exposed and the glands are brought into view by stripping it upwards and backwards. A glandular abscess can form in the iliac fossa, as a result of an infected wound of the lower extremity, without any material enlargement of the inguinal glands, and may be mistaken for a chronic appendicitic abscess or a psoas abscess, unless the local lesion is detected.

When disease of the glands of the groin is clearly but a part of a general glandular infection, it is doubtful whether surgical interference is called for, unless suppuration occurs.

The **popliteal glands** are rarely affected, but, if diseased, may

be removed through a longitudinal incision, the relations of the vessels and nerves being borne in mind.

LYMPHATIC OBSTRUCTION

Any form of obstruction of the lymphatic vessels may give rise to temporary or permanent disturbances, according to the ability of the collateral lymphatics to deal with the flow of lymph. Œdema, or even dilatation and rupture of the lymphatic vessels, may occur. The œdema thus produced may be very slight, or such as to cause an enormous solid swelling of a limb with great hypertrophy of the skin and other tissues. Lymphatic and venous obstruction are very frequently associated, and determination of their relative importance in the causation of the œdema may be difficult. The lymphatic anastomoses are so free that the collateral circulation is, as a rule, readily established, and even the removal of large groups of glands such as the axillary rarely causes signs of lymphatic obstruction. Œdema is occasionally met with after removal of these glands, particularly when infection and suppuration of the wound have occurred, but it is usually temporary. Sometimes, when associated with much fibrous thickening in the axilla, it may be permanent, but, when progressive, in the great majority of cases it is due to the gradual invasion of the lymphatic system by malignant disease

Widespread obliteration of the small collateral lymph-channels, as well as of the main trunks, appears to be essential to the production of lymphatic œdema.

Filariasis is the commonest cause of lymphatic obstruction (*see* Vol. I., p. 958).

Solid œdema of congenital origin is sometimes met with, affecting usually the lower limbs, and due apparently to a developmental defect in the lymphatic vessels. In some cases of this kind the affection appears to be hereditary. The œdema tends to increase slowly, and is not much influenced by treatment.

Œdema following obliterative lymphangitis.—In every attack of lymphangitis, obliteration of a certain number of lymphatic vessels occurs. When of limited extent there is no noticeable obstruction to the lymphatic return, but when the inflammatory affection is widespread, as in some cases of puerperal sepsis, or when attacks frequently recur, then a greater or lesser degree of lymphatic obstruction is apt to take place.

Puerperal white-leg—The white, solid, painful œdema of the leg which occurs in some cases of puerperal sepsis is due in part to phlebitis of the pelvic veins and in part to obliterative lymphangitis. A similar form of œdema is met with in other inflammatory affections of the pelvic viscera, such as suppurative appendicitis.

A widespread lymphangitis following a septic wound of the hand may cause a painful, disabling œdema, which, however, tends to recover. Repeated attacks of lymphangitis of a limb without apparent cause may lead to the development of a solid œdema which cannot be distinguished clinically from true elephantiasis.

Facial erysipelas is sometimes followed by the development of a solid œdema which affects principally the eyelids, though the face and lips may be involved.

Multiple gummata, particularly of the leg, are sometimes associated with an œdematous condition of the limb which appears to be the result of lymphatic obliteration, and may be so extreme as to resemble elephantiasis.

Œdema due to cancerous obstruction of lymphatic vessels is most often met with in the upper limb as a sequel to mammary carcinoma (*see* Vol. II., pp. 70, 102) At a variable period in the development of the disease œdema appears, usually at the wrist, and gradually involves the whole limb, sometimes spreading on to the shoulder and the chest wall. The œdema is of the solid variety, is accompanied by intense pain, and eventually by paralysis of the limb, the arm is cold and more or less cyanosed. This form of œdema is not due to interference with the venous return from the limb, as cases are met with where there is no œdema, though the axillary vein is completely obstructed by growth, or has been removed at the operation for carcinoma of the breast. The œdema cannot be due entirely to the obliteration of the main lymphatic channels by growth in the glands, as it is frequently absent in cases where the glands are found to be extensively diseased. Moreover, œdema is very rarely met with at once after the complete operation for carcinoma mammæ, where all the lymphatic glands in the axilla are removed and where the main lymphatic channels are necessarily interrupted. According to Handley, brawny œdema of the arm is due to blocking not only of the main lymphatic channels, but also of all the collateral routes about the shoulder, owing to permeation of the lymph-vessels by cancer cells and to perilymphatic fibrosis.

Treatment of œdema following lymphatic obstruction.—For the slighter degrees of œdema following operations, wounds, lymphangitis, or erysipelas, nothing is necessary but rest and elevation of the part, with massage and firm bandaging. The œdema will disappear as the collateral circulation becomes established. In the congenital variety of the affection little can be done. When œdema is associated with gummatous ulceration, appropriate anti-syphilitic treatment should be adopted.

The operation of lymphangioplasty has been practised in some cases of lymphatic obstruction, particularly in the treatment of the

brawny arm of cancer of the breast. The relief given is sometimes considerable, but recurrence is the rule, and the operation is now generally abandoned.

Lymphangiectasis

Apart from filariasis, dilatation of the lymphatic vessels as a result of obstruction is a rare event. In some cases the obstruction appears to be of congenital origin, in others it follows injury or attacks of lymphangitis. The lymphatics are dilated, tortuous, and distended with lymph. Small cysts are frequently met with in the skin, and these may give way, a profuse discharge of lymph resulting. If limited in amount the mass of dilated vessels may be dissected out, but if extensive it can only be protected from injury and infection.

Lymphangioma

These simple tumours arising in lymphatic vessels are analogous to the angiomas. Three varieties are commonly described:

Nævoid lymphangiomas form small, pink, slightly elevated tumours which occur on the skin or mucous membranes. Little cystic dilatations may be seen on the surface of the tumour, which sometimes rupture and discharge lymph. A nævoid lymphangioma affecting the tongue (*see* Plate 87, Vol. II., facing p. 214) may extend deeply into the muscular tissue and cause great enlargement of the organ (macroglossia). A similar condition in the lip produces one form of macrocheilia

The smaller tumours are best treated by excision; when extensive, as in the tongue or lip, if excision is impracticable, electrolysis is sometimes successful

Cavernous lymphangioma is sometimes known as cystic hygroma The tumour is noticed at birth, and usually increases in size for a time. It is commonly met with in the neck, and forms an irregular multilocular cystic swelling passing beneath the sterno-mastoid muscle and extending into the posterior triangle or even into the axilla. The tumour consists of a number of cysts lined with a single layer of flattened lymphatic epithelium and containing limpid fluid. The cysts are bound together by a varying amount of fibrous and fatty tissue, and the mass is adherent to muscles, to the vascular sheaths, and generally to the skin. These tumours are very liable to attacks of inflammation, becoming swollen and tender, with redness of the skin and elevation of temperature; suppuration is very rare. The tumour is not infrequently found to be rather smaller after the attack has subsided, and it may disappear as a result of repeated attacks, leaving only a small mass of scar tissue.

The treatment of these tumours is unsatisfactory; their wide extent, absence of encapsulation, and adhesion to important structures render excision very difficult, and in many cases impossible. Tapping and injection of the cysts is not to be recommended, owing

to the danger of sepsis. They are best left alone, and will frequently disappear, perhaps after repeated attacks of inflammation.

Cystic lymphangioma. Single lymphatic cyst (Fig. 651).—Cystic lymphangiomas are usually met with in the neck. Such a cyst forms a globular swelling, smooth, fluctuating and elastic, of slow growth, and not accompanied by symptoms The cyst is thin-



Fig. 651 —Lymphatic cyst.

walled, lined with lymphatic epithelium, and contains clear fluid. In the neck it lies beneath the sterno-mastoid muscle, and may protrude in front of or behind the muscle It may be dissected out with ease, as it is not adherent to other structures.

LYMPHATISM

This affection, though not amenable to surgical treatment, is of interest to surgeons as a cause of sudden death during and after operations. The disease is occasionally suspected though rarely diagnosed during life, and is usually revealed on post-mortem examination. It is most frequently met with between the ages of 12 and 22, though it has been seen during the first year of life and as late

as 50. A post-mortem examination of a typical case reveals hyperplasia of the lymphatic tissue throughout the body; the lymphatic glands, tonsils, adenoid tissue in the naso-pharynx, lymphoid tissue of the back of the tongue, spleen, Peyer's patches in the small intestine, and lymphoid follicles in the large bowel being all affected. The thymus gland is commonly greatly enlarged; the heart is usually rather dilated and the heart muscle degenerate.

The striking feature of this condition is the liability to sudden death after any trivial injury or shock, and particularly during anæsthesia. A slight burn, a warm bath, mental excitement, have each proved the determining factor. A large proportion of the deaths have occurred during the removal of enlarged tonsils and adenoids, and during anæsthesia with chloroform, though death has even followed the employment of a local anæsthetic.

The recognition of lymphatism before any operation is performed is extremely important. The difficulty in diagnosis is, however, so great that at present it is to be expected that occasional deaths will occur. The careful examination of a large number of cases of enlarged tonsils and adenoids in children revealed two cases in which there was good reason to believe that the condition of lymphatism existed, and in which, therefore, no operation was performed. Even if lymphatism is merely suspected, any proposed operation should be deferred. Suggestive symptoms are: enlarged lymphatic follicles at the base of the tongue, enlarged tonsils with adenoids, a general even if slight enlargement of lymphatic glands, any evidence of enlargement of the thymus, such as fullness of the suprasternal notch with increased dullness behind the manubrium sterni, distant and muffled heart-sounds with a feeble pulse.

If any form of operative treatment is urgently indicated in a patient suspected of lymphatism, general anæsthesia by ether administered by the open method would appear to be safest.

TUBERCULOUS LYMPHANGITIS

Tuberculosis of the lymphatic vessels is frequently met with in advanced disease of the internal organs, particularly the intestine and the lung. The diseased vessels may be seen in the subserous tissues as if injected with a white or yellow material, even the beaded appearance, so regularly seen in anatomical specimens, being maintained. In the mesentery the diseased vessels can frequently be traced upwards to an enlarged lymphatic gland, but the largest lymph-channels are not commonly affected. In the limbs the lymphatic vessels are rarely attacked, though they are frequently the channels by which tubercle bacilli are conveyed to the glands.

Tuberculous lymphangitis of the vessels of the extremities usually

follows some accidental inoculation with the bacillus. The port of entry of the bacillus may not be apparent, or a definite tuberculous lesion may develop at the point of inoculation, a tuberculous wart or ulcer. It may complicate any form of tuberculous disease of the skin, sometimes even arising from the margin of a sinus leading down to a diseased bone or joint.

Pathology.—The affected vessels become thickened and obliterated by cellular proliferation; a perilymphangitis occurs, and in time definite tuberculous nodules form in the course of the affected vessel, which break down, invade the skin, and discharge, leaving a tuberculous ulcer. The thickened vessels can be felt under the skin between the nodules and running upwards towards the nearest group of glands, which are frequently enlarged. Extensive ulceration of the skin may spread from one of the ulcerated nodules in the course of the lymphatic vessel. Lymphangiectasis has been noted in some extensive cases of tuberculous lymphangitis, cysts forming in the skin as a result of the obstruction of the larger vessels; these may rupture and discharge lymph, perhaps in considerable quantities.

Diagnosis.—The only conditions likely to cause diagnostic difficulties are multiple syphilitic gummata in the skin, and chronic glanders affecting the lymphatic vessels. *Gummata* are not arranged in the course of the lymphatic vessels, they are not associated with a primary lesion in the skin, the lymph-glands are unlikely to be much enlarged, and there may be other signs of syphilis. *Chronic glanders* may cause great difficulty in diagnosis; the breaking-down nodules lie in the line of the lymphatic vessels, and there may be a primary lesion of the skin, perhaps following a wound. Tuberculous lymphangitis is closely simulated by the chronicity of the affection and its resistance to treatment. Suspicion may be aroused if the patient has the care of horses, and the mallein or inoculation test should then be employed (*see* Vol. I., p. 907).

Treatment.—Early and efficient treatment of all local tuberculous skin affections will prevent tuberculous lymphangitis Wounds infected with the tubercle bacillus, tuberculous warts and ulcers, should be treated by excision. When the condition is established, excision of the primary focus, the nodular and thickened vessel, and the enlarged glands is the ideal method of treatment. In very extensive cases this may be impracticable, and reliance must be placed on curetting, the application of iodoform or zinc chloride, with general and hygienic treatment on the lines previously indicated.

WOUNDS OF LYMPHATIC VESSELS AND GLANDS

Every wound involves the laceration of lymphatic vessels, though, apart from infection, serious consequences are rarely seen. Very

occasionally, when a large lymphatic vessel is divided, healing is delayed by a more or less profuse discharge of lymph, and a lymphatic fistula may persist. This has been noticed after the incision or removal of lymphatic glands, particularly in the groin, and after such operations as abdominal hysterectomy for carcinoma of the uterine cervix, where cellular tissue is widely opened and numbers of lymphatic vessels are divided. Lymphorrhagia undoubtedly favours infection of a wound, and the combined effects of sepsis and loss of lymph may lead to the death of the patient. It may be treated by drainage and firm compression of the wound.

ACUTE LYMPHANGITIS AND LYMPHADENITIS

Acute lymphangitis is to be regarded as the result of the reaction of the lymphatic plexus and vessels to the invasion of an infective agent. The organism commonly found is the streptococcus pyogenes, though staphylococcal and mixed infections occur. The infective agent gains entry to the lymphatic vessels through a solution of continuity in the skin or mucous membrane, and the point of entry may or may not be apparent. The most severe infections are to be noted in cases where the lesion is very minute, or where there has been no obvious breach of surface. The commoner lesions which lead to an attack of lymphangitis are pricks or cuts sustained in the post-mortem room or operating theatre, rarely in the dissecting room, scratches from pins or nails, pustular affections of the skin, etc. Incised wounds, if carefully treated, are rarely followed by lymphangitis, though it is not uncommon after lacerated wounds into which dirt may be ground. The severity of the affection varies from a slight temporary discomfort and throbbing with redness of the skin, to a fulminating process with gangrene and septicæmia. Much, of course, depends on the virulence of the infecting agent, but more on the resisting power of the patient. Severe lymphangitis is not common in the healthy individual; it occurs in those living under unfavourable conditions and getting little exercise, in alcoholics, in diabetics, and in the subjects of chronic interstitial nephritis. So-called epidemics of lymphangitis have been met with among troops, and on board ship when there has been a deficiency of fresh water and food.

Two types of lymphangitis may be recognized, retiform and tubular. *Retiform lymphangitis*, in which the inflammation affects the lymphatic plexuses and smaller vessels in the skin and subcutaneous tissues, is characterized by the presence of a diffuse superficial redness of the skin around the point of inoculation. The reddened area has an irregular margin, is warm to the touch and tender on pressure. There are pain and a sensation of heat and throbbing

in the part, and constitutional disturbance which may be slight or very severe, with rigors, elevation of temperature, headache, vomiting, and prostration. It may be difficult at times to distinguish a lymphangitis from erysipelas, but the presence of red lines in the skin denoting the spread to the lymph-vessels will serve to distinguish the two affections.

Tubular lymphangitis is associated with reticular lymphangitis and is the result of the spread of infection to the lymph-vessels themselves. It is characterized by the presence of red lines in the skin, denoting the course of the inflamed vessel and leading up the limb to the associated lymphatic glands. There is tenderness on pressure over these red lines, and sometimes a brawny infiltration will be felt around the vessel. On microscopical examination such a vessel will be found distended with a fibrinous clot, its walls infiltrated with cells and surrounded by a zone of perilymphangitis.

The inflammatory process, both in the smaller and the larger lymphatics, may, and not infrequently does, terminate in complete resolution. Suppuration is common at the seat of inoculation, and either a definite localized abscess may form or a more diffuse suppuration occur in the cellular tissue. Sometimes—and this particularly in diabetics or the subjects of chronic nephritis—bullæ appear on the skin, then dark patches of gangrene spreading rapidly and associated with general symptoms of corresponding severity. Suppuration around the larger lymphatics is not common, but when it does occur a chain of abscesses may be met with in the course of the involved lymph-channel.

Treatment of acute lymphangitis.—The immediate antiseptic treatment of all wounds, however trivial, would do much to prevent the occurrence of acute lymphangitis. When it is established, energetic treatment will diminish the likelihood of local or glandular suppuration. If the original wound is of the punctured variety, it should be laid freely open by an incision; if an incised or lacerated wound has been sutured, all stitches should be removed and every recess laid open. The most rapidly effective measure for combating the local infective process is by the Carrel-Dakin method (*see* Vol I., p. 282). The original Dakin's solution is, however, very irritating to the skin, and it may be diluted. Other methods, such as continuous irrigation, antiseptic baths, fomentations, etc , are far less efficacious. If there is extensive œdema of the limb with great pain, relief may be given by multiple incisions, even when there are no signs of suppuration. If pus-formation is evident, the pus should be evacuated by wide incisions, and efficient drainage provided. If constitutional disturbance is marked and symptoms of septicæmia are present, general treatment is indicated. Much good frequently results from the

administration of stimulants. Saline injections, administered per rectum, intravenously, or subcutaneously, promote the elimination of toxins and improve the general condition of the patient. *Vaccine-therapy* is an important aid in dealing with the septicæmic type of acute lymphangitis; an autogenous is much to be preferred to a stock vaccine. Antistreptococcic and antistaphylococcic *serum* has been employed with some success, though it is now recognized that the results of serum treatment are inferior to those obtained by vaccine injections. The indiscriminate use of serums or vaccines without previous identification of the causative organism is to be deprecated, and before such methods are employed it is essential that any focus of suppuration be evacuated.

Acute lymphadenitis is the result of infection of glands by organisms carried, as a rule, in the afferent lymphatic vessels, and is associated or not with an acute lymphangitis. A lymphangitis of any severity is always accompanied by some degree of enlargement and inflammation of the associated glands, and these are to be regarded as a barrier to the spread of the infecting organism into the general circulation. Acute lymphadenitis occurs after wounds, slight pricks, and excoriations, in pustular affections of the skin and mucous membranes, malignant pustule (anthrax), as a result of carious teeth, acute tonsillitis, scarlet fever, diphtheria, etc. It is also met with after typhoid and typhus fever, smallpox, and even acute pneumonia, though in such cases it is probable that the infection of the glands is not hæmatogenous, but is associated with some small lesion in the tributary area of the affected glands which has not been noticed. It is but rarely met with in inflammatory affections of the deeper structures of the limbs, such as acute arthritis, or acute infective osteo-myelitis. Acute lymphadenitis is always accompanied by œdema and infiltration of the cellular tissue around the gland which fixes it to its neighbours and to other structures and obscures the outlines of individual glands. Resolution occurs in the majority of cases, but suppuration is frequent. The gland substance softens and breaks down, pus-containing cavities resulting; the capsule gives way, and a localized or diffuse suppuration in the periglandular cellular tissue follows. In very virulent infections, or when the resisting power of the patient is low, the suppurative process may spread widely and rapidly, and be attended by sloughing of the skin and cellular tissue and by symptoms of profound septic intoxication Symptoms frequently commence with a rigor and elevation of temperature; the patient complains of pain in the affected part, and the glands are enlarged and tender, with ill-defined outlines. If suppuration occurs a brawny swelling forms, with redness and heat of the skin, and after a time softening and fluctuation will be recognized.

Constitutional symptoms vary from a slight malaise to a profound septicæmia.

Treatment of acute lymphadenitis.—In general, in the early stages this resolves itself into the treatment of the primary affection. Carious teeth are extracted, a tonsillar or alveolar abscess is opened, a septic wound thoroughly cleaned and drained; if lymphangitis is present, local treatment on the lines indicated is necessary. In most cases, with efficient and timely attention to the causative affection, acute lymphadenitis will subside. Hot fomentations will relieve pain and stiffness, and if suppuration occurs the resulting abscess should be opened as soon as possible.

Acute Lymphadenitis of Different Gland Groups

Superficial glands of the head and neck.—The occipital, mastoid, parotid, and superficial cervical glands are usually infected from local affections of the scalp or auricle. Suppuration of these glands is not common, and when it does occur the resulting abscess is readily dealt with An abscess arising in the mastoid glands must not be mistaken for one of bony origin. Abscess in the parotid glands must be opened by a transverse incision, the greatest care being taken to avoid wounding the facial nerve or its branches.

Deep cervical glands.—Acute inflammation of these glands is very commonly met with in association with septic foci in the mouth, pharynx, etc, or as a sequel to the exanthemata. With early and radical treatment of the primary lesion the glandular enlargement will frequently subside, but suppuration is common, and the resulting abscess may be localized or may spread rapidly beneath the deep fascia of the neck. Septic thrombosis of the internal jugular vein may occur, or even ulceration into the internal carotid artery. Deeply situated abscesses at the root of the neck may extend into the chest and give rise to a mediastinal abscess, to pleurisy, or pericarditis. Sometimes an abscess of the deep cervical glands will result from a septic focus of the face or scalp; the infecting organisms being carried by those afferent vessels which, missing the superficial glands, run directly to the deeper ones. During the stage of acute adenitis, torticollis may be present, the head being fixed by muscular contraction in the effort to prevent pressure on the inflamed and tender glands; and after an abscess has been opened the resulting matting of muscles and contraction of fascia may be sufficient to give rise to a permanent deformity. Early incision and drainage is necessary when an abscess forms, to prevent burrowing of pus, and the skin incision should be made over the swelling in an oblique direction following the normal folds of the skin. When the deep fascia is incised the abscess may be entered at once; if not, a pair of sinus

forceps may be thrust into the swelling and the orifice dilated (Hilton's method) Necrosed tissue is removed, pus wiped away, and the abscess cavity treated by the Carrel-Dakin method (Vol. I., p. 282). Efficient drainage is provided by means of a rubber or glass tube, and the neck enveloped in a large aseptic dressing.

Acute retropharyngeal abscess (*see also* p. 292) is the result of inflammation of the **lateral pharyngeal glands,** of which there are usually two or three on each side, lying between the pharynx and the prevertebral fascia, and receiving lymph from the nasal and naso-pharyngeal mucosa. Suppuration is a not uncommon event in small children, and is apt to be overlooked. The resulting abscess forms a swelling behind the lateral and posterior wall of the pharynx, which bulges forwards into the pharyngeal cavity. There is dyspnœa with a crowing respiration; the child assumes a typical attitude, the head thrown back, the mouth open, and the tongue protruded; the soft palate will be seen pushed forwards by a soft, fluctuating swelling on the postero-lateral aspect of the pharynx. An acute abscess of this type is to be distinguished from an abscess the result of tuberculosis of the lateral pharyngeal glands, which will be accompanied by evidence of disease in the more superficial glands, and from an abscess due to caries of the cervical spine, which lies behind the prevertebral fascia, may be mesial in position, and is associated with signs of bone disease. An acute retropharyngeal abscess, if not opened, extends downwards behind the pharynx and outwards behind the vessels into the posterior triangle of the neck; it may burst into the pharynx and cause death from suffocation; but if this danger and that of septic pneumonia from inhalation of pus are escaped, recovery may follow evacuation.

The abscess may be opened into the pharynx by thrusting a pair of sinus forceps into the prominent swelling and opening the blades; this should be done with the head hanging downwards to prevent aspiration of pus, and in extreme cases the operation may be readily performed without an anæsthetic. This is the method of choice in babies, and when the symptoms are urgent. In older children the abscess may be opened through an incision in the neck behind the posterior border of the sterno-mastoid, the vessels being pushed forwards and the cavity entered by Hilton's method.

Glands of the upper extremity.—Acute lymphadenitis of the **axillary glands** is often met with in cases of septic wounds of the hand, lymphangitis, whitlow, etc, and suppuration is frequent. A brawny mass is found filling up the axilla, and the patient complains of pain on movement of the arm, either in abduction, which compresses the glands by the axillary fascia, or in adduction, which squeezes the glands against the chest wall. It

is not always easy to determine when suppuration has occurred, owing to the dense axillary fascia overlying the glands, and in cases of doubt an early exploratory incision should be made. If unopened an axillary abscess will extend widely beneath the pectoral muscles and between the scapula and the chest wall, and may ulcerate into the axillary artery or vein The abscess should be opened by a free incision across the middle of the axilla parallel to the lower border of the pectoralis major muscle; care must be taken not to wound the axillary vessels and nerves or the long thoracic artery. If deeply situated, the abscess may be opened by Hilton's method.

Delayed resolution is sometimes met with in the axillary glands after an acute lymphadenitis, the glands remaining enlarged and tender. Such an inflamed mass of glands is sometimes removed to expedite recovery, and small foci of necrosis will be found in the glands, though without any periglandular suppuration. It is questionable whether excision of such a mass of glands is a wise proceeding. There are cases in which, following removal of the glands, the patient has been particularly liable to severe constitutional symptoms after even the most trivial septic wound in the corresponding lymphatic area. This is explained by the fact that the barrier between the superficial lymphatic vessels and the general circulation has been largely destroyed by the removal of the axillary glands. When delayed resolution is met with, the arm must be kept at rest in a sling and counter-irritation applied. If pain and swelling continue the axilla should be opened, the glandular mass incised, and a drainage-tube inserted. On no account should the whole mass of glands be excised, though one or two, more evidently diseased than their fellows, may be removed. An autogenous *vaccine* may be of great value in the treatment of such a case.

Acute lymphadenitis of the **supracondylar** and **brachial glands** and of the glands at the termination of the cephalic vein will sometimes be found. If suppuration occurs the resulting abscess will be easily opened; in the case of the brachial and cephalic glands care must be taken of the important structures with which the abscess will be in contact.

Glands of the lower extremity.—Venereal disease, in some form, is the most common cause of acute inflammation of the **inguinal glands** (*see* Vol. I, p. 874), though any septic focus in the area draining into them may be responsible, such as septic wounds or ulcers of the leg, boils on the buttock or around the anus, anal ulceration, pediculosis pubis, eczema of the scrotum, etc. A very thorough search may be necessary before the primary lesion, which may be very small, is detected. When the infection is derived from the skin of the lower extremity, as a rule the infero-internal

and infero-external glands will be the first to enlarge, the majority of the vessels being intercepted by these glands, infection thence spreading to the *supero-internal and supero-external groups. When* the infection arises from the scrotum the supero-internal, and perhaps the infero-internal, will be enlarged; and the supero-external will be affected from a lesion on the skin of the buttock. Acute lymphadenitis in this region frequently terminates in suppuration, but as the glands are superficial it is often possible to incise the suppurating gland before the periglandular tissues are affected. As in the case of the axillary glands, excision of inflamed glands is not to be recommended.

Iliac glands.—Occasionally, as a sequel to a septic wound of the lower extremity, enlargement of the glands lying in the iliac fossa external to the external iliac artery may be observed, and an abscess may form here with or without any inflammation of the inguinal glands. *Such an abscess may simulate very closely an appendix* abscess or even a psoas abscess, and mistakes in diagnosis are likely to be made if the limb is not carefully searched for a primary lesion. Such an abscess may be opened and drained through an incision parallel to and a little above the outer part of Poupart's ligament; after division of the aponeurosis of the external oblique, the internal oblique and transversalis muscles are split in the line of the muscular fibres, and the abscess reached by stripping forwards the peritoneum.

The **popliteal glands** are occasionally infected from a septic focus on *the outer aspect of the leg or foot. If an abscess forms it* may usually be reached in the upper part of the popliteal space by an incision in front of the tendon of the biceps. In the lower part of the space a vertical incision may be employed, care being taken of the vessels and nerves.

Abdominal lymphatic glands.—Acute inflammation of the various groups of glands inside the abdomen is very infrequently recognized; in fact, our knowledge of the condition is practically limited to one group of glands, viz. the ileo-colic. During operations for acute appendicitis, particularly when done at an early stage before suppuration *has occurred or adhesions have formed,* a chain of enlarged lymphatic glands may sometimes be found running upwards from the ileo-colic angle towards the duodenum. It is evident that resolution of the inflammation usually takes place, but suppuration does sometimes occur, and persistence of the symptoms of pain, vomiting, elevated temperature, and perhaps a palpable swelling, may be due to a glandular abscess. On opening the abdomen a swelling will be found in the angle between the termination of the ileum and the ascending colon behind the peritoneum; the abscess

may be opened by tearing through the peritoneum, care being taken of the ileo-colic vessels. It is probable that glandular abscesses are not infrequently opened during operations for acute appendicitis without their true nature being recognized, and some of the cases of "delayed" abscess after appendicitis are probably of this nature.

GLANDULAR FEVER

This is an acute infectious disease, principally of children, characterized by rapid enlargement of the cervical glands and by a less constant enlargement of the axillary, inguinal, and other glands, and of the liver and spleen. The onset of the disease is sudden, with restlessness, loss of appetite, constipation, furred tongue, rapid pulse, and occasionally vomiting. Abdominal pain is sometimes present, and may be severe. The upper deep cervical glands are most commonly affected, at first unilaterally and then bilaterally. Suppuration is uncommon. The prognosis is favourable, the enlargement of the glands usually subsiding after the fifth or sixth day. The etiology is unknown. The disease may be mistaken for acute lymphadenitis and other affections which are associated with rapid enlargement of the lymphatic glands.

LYMPHADENOMA (HODGKIN'S DISEASE)

Lymphadenoma is characterized by enlargement of the lymphatic glands, liver, and spleen, associated with anæmia and wasting, usually with a fatal termination within three to four years. It occurs more frequently in males than in females, and is most common in children and young adults.

The disease commences as an enlargement of one or other group of lymphatic glands, usually the upper deep cervical glands. Other glands of the neck are attacked, and the affection spreads to the opposite side of the neck and the axilla (Fig. 652.) In time all the glands of the body may be attacked. The diseased glands are firm, elastic, discrete, and movable; there is no periadenitis, and in uncomplicated cases no tendency to softening or suppuration. In many cases attacks of fever occur from time to time, and the glands have been noticed to increase in size during these attacks As a result of pressure of the enlarged glands on the trachea, the œsophagus, or the great veins in the mediastinum, such symptoms as dyspnœa, dysphagia, œdema, and cyanosis may arise. Marked anæmia is a feature of the disease, the blood examination showing deficiency both in red cells and in hæmoglobin, with no leucocytosis in the absence of secondary infections. Enlargement of the spleen and liver is common in the late stages of the disease. Death is usually the result of an intercurrent infection, not infrequently tuberculosis, and sometimes

the progress of the disease may be very rapid, death occurring within a few months of the onset.

Pathology.—On section the lymphadenomatous gland is firm and fleshy, and shows islets of fibrous tissue on the cut surface; there are no areas of softening and liquefaction as in the tuberculous gland, Microscopically the normal gland tissue (Plate 110, Fig. 1) is seen

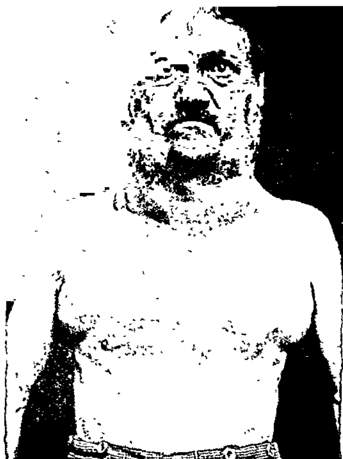


Fig. 652.—Case of Hodgkin's disease.

to be replaced by a reticulum and connective-tissue stroma (Plate 110, Fig. 2), which is denser and more conspicuous in the older lesions, and in the meshes of which lie lymphoid cells, large irregular ("giant") cells with a large vesicular nucleus or nuclei, and eosinophile cells, which are, however, inconstant.

Nodules of the tissue may be found in the spleen (Fig. 653) and liver, and indeed in any lymphoid tissue (Reed). The appearance of a microscopic section is quite different from that of a tuberculous

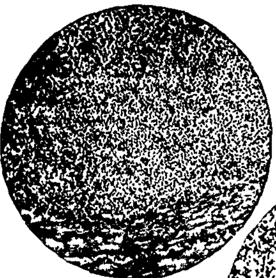


Fig 1—Section of lymphatic gland from case of Hodgkin's disease, showing normal structure

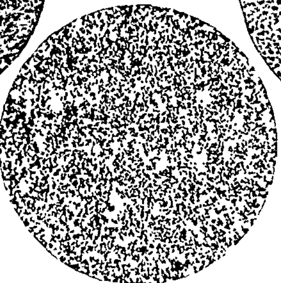


Fig 3 Gland from case of lymphatic leukæmia

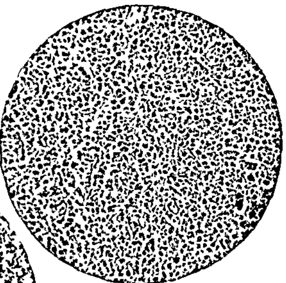


Fig 2—Section of lymphatic gland from same case as in *Fig 1*, *showing* diseased tissue

PLATE 110.

gland, and is so characteristic that a definite diagnosis can generally be made.

Bunting and Yates have isolated a diphtheroid organism from the lymphatic glands, which they regard as the cause of the disease; but the same organism has also been found in cases of chronic leukæmia, lympho-sarcoma, chloroma, etc.; and other observers, e g. Rosenow, have found staphylococci and streptococci in the lymphatic glands. Inoculation experiments with this diphtheroid organism and with fragments of gland tissue have been inconclusive.

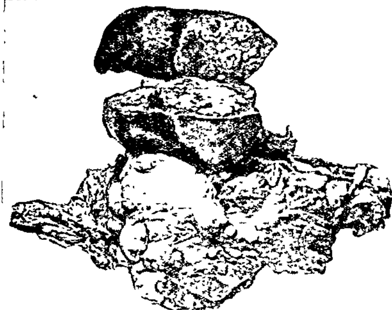


Fig. 653 —Deposits in the spleen in Hodgkin's disease.

Lymphadenoma has been regarded by some observers as merely a variety of tuberculous lymphadenitis, but inoculation experiments prove that this is not the case The difficulty has arisen because tuberculosis is not infrequently met with in cases of Hodgkin's disease as a terminal infection, and also because the pseudo-lymphadenomatous variety of lymphatic tuberculosis is not uncommon. The majority of authors maintain that Hodgkin's disease is due to an infective agent; this theory is supported by the fact that it usually begins in the glands of the neck and spreads gradually to other glands, that it is commonly accompanied by periods of fever, and that the enlargement of glands increases at these times. According to Mueller, however, the assumption of a purely infectious origin cannot

satisfactorily explain the fact that Hodgkin's disease in its pathological and clinical course shows certain of the properties of a neoplasm. There is tumour-formation with very little necrosis; adjacent structures are invaded and destroyed, and, though the disease is at first local, in time metastases are found in distant organs. Mueller thinks that Hodgkin's disease and lympho-sarcoma are closely associated, and that they are merely different expressions of the same process.

Diagnosis.—Lymphadenoma is to be distinguished principally from leukæmic gland enlargements (Plate 110, Fig 3), from lympho-sarcoma, from syphilitic and tuberculous lymphadenitis. A blood-examination, which should always be made, will exclude *leukæmia.* The mobility of the glands and the absence of fixation or infiltration of surrounding tissue distinguish lymphadenoma from *lympho-sarcoma,* and the absence of other lesions will eliminate *syphilitic lymphadenitis.* The principal difficulty arises in connexion with the lymphadenomatous form of *tuberculous lymphadenitis.* In the later stages of the disease there will be little difficulty, particularly when the spleen is enlarged, though it must be remembered that this may occur in tuberculosis. In the early stages a correct diagnosis can only be assured by the examination of a gland removed for the purpose, and this should always be done.

Treatment.—The surgical treatment of lymphadenoma is most unsatisfactory. Even the most radical operations—e.g. block dissection of the neck—are of no avail in arresting the disease. Excision of glands followed by X-ray or radium treatment has been practised, but there seems no reason to believe that the results are any better than in cases treated by irradiation alone.

X-ray treatment has been extensively employed, and in many cases the glands diminish in size and the progress of the disease is arrested for a time. Radium often causes rapid disappearance of local manifestations, and in some cases the disease appears to be arrested. Burnam reports some very favourable cases of freedom from recurrence after some years, even when the mediastinum has been invaded.

Coley's fluid has been used, but appears to be of little value. Arsenic is usually given; it improves the anæmia for a time, but has little effect on the progress of the disease. The intravenous administration of the newer arsenical preparations is of no value.

LYMPHO-SARCOMA

This variety of sarcoma may originate in the lymphoid tissue of any part of the body, but it usually commences in lymphatic glands. The upper deep cervical group of glands is the one most commonly affected, and the growth forms a rapidly increasing tumour which

spreads from gland to gland, extends beyond the gland capsule, and quickly invades the surrounding tissues. Fixation of the mass to the surrounding structures occurs early; cachexia is a prominent symptom, and as the tumour increases in size serious symptoms may arise from pressure on the larynx, trachea, œsophagus, and vessels and nerves. Severe neuralgic pain is common. After a time the centre of the mass degenerates, softens, and becomes fluctuant; the skin gives way, with a discharge of blood-stained fluid and tumour débris, and severe hæmorrhage may cause death. Fungation of the growth is sometimes seen, and a profuse foul-smelling discharge adds to the miseries of the patient. As a rule, the disease appears to extend by means of the lymphatic channels, though metastases occur which can only be explained by transformation of the neoplastic elements by means of the blood-stream. Death occurs either from cachexia, hæmorrhage, or pressure effects.

Microscopically, the growth consists of masses of small round cells with a well-marked nucleus and of very little fibrous stroma.

In the very earliest stages of the development of a lympho-sarcoma of the cervical glands an accurate diagnosis is extremely difficult. The condition may be mistaken for lymphadenoma or for a chronic or tuberculous lymphadenitis. Accurate diagnosis at this early stage, when it is so important, can only be made by removing a portion of the mass for microscopical examination if a suspicion of its possible malignant nature is aroused by a steady and rapid increase in size. When fixation has occurred the only condition likely to be mistaken for lympho-sarcoma is malignant disease secondary to a primary focus in the mouth, pharynx, etc. This should be excluded by a careful examination.

Treatment.—The surgical treatment of lympho-sarcoma of lymphatic glands is exceedingly unsatisfactory. Almost invariably the condition is first seen by the surgeon when fixation and infiltration of surrounding parts have reached such a degree that complete removal of the disease is out of the question. For the consideration of the various points involved in determining the feasibility or otherwise of operative treatment, and its scope, the reader is referred to the section on the treatment of secondary malignant glands (p. 193).

When operative treatment is impossible, as is generally the case the progress of the disease may in some cases be arrested by irradiation. X-rays appear to be inferior to radium, which should be applied by burying a capsule containing radium in the substance of the mass. The information at present available is insufficient to enable one to determine accurately the ultimate value of radium treatment, but there can be no doubt that it arrests the progress of the disease for a time.

Coley's treatment by the injection of mixed toxins of *Streptococcus pyogenes* and *Bacillus prodigiosus* has been extensively employed, and Coley himself has reported a number of undoubted cases of lympho-sarcoma apparently cured by this method. Injections of the fluid may be given every other day; the initial dose should be small ($\frac{1}{16}$ minim), and is gradually increased according to the amount of reaction. This is apt to be severe, with rigors, elevation of temperature, rapid pulse, and sometimes great prostration. In the hands of most surgeons this method of treatment has proved extremely disappointing.

The occurrence of dyspnœa from pressure on the larynx or trachea may call for the performance of a tracheotomy; when the neck is extensively infiltrated with growth the operation may be one of extreme difficulty.

INVASION OF THE LYMPHATIC SYSTEM IN CANCER

The primary neoplasms met with in the lymphatic glands are usually lympho-sarcomas. Primary carcinoma has been described, particularly in the case of the cervical and the mediastinal glands, but these cases are usually capable of other explanations, and at the present time the occurrence of primary cancer in lymphatic glands cannot be considered as proved. An epithelioma can arise in the remains of the branchial clefts, and forms a rapidly growing malignant tumour in the neck, which simulates very closely a glandular tumour; it infiltrates surrounding structures, breaks down rapidly, and is associated with secondary deposits in the surrounding lymphatic glands. On examination the tumour is found to be an epithelioma, and, in the absence of a primary growth, may be regarded as having its origin in a gland. There is some reason also to believe in the possibility of a primary epithelioma developing to a certain size and producing deposits in glands, which continue to grow while the primary tumour disappears. In other cases a small epithelioma of the pharynx, back of the tongue, or œsophagus may escape observation while the secondary glandular growths are developing rapidly. Primary cancer of the mediastinal glands may be simulated by a tumour having its origin in the thymus remains, and in some cases an alveolar sarcoma may resemble a carcinoma very closely.

The secondary invasion of the lymphatic system in cancer may be considered in two aspects—as it affects the lymphatic vessels, and as it affects the lymphatic glands.

Invasion of lymphatic vessels.—The spread of cancer in lymphatic vessels has been more thoroughly understood in recent years as a result of the laborious investigations of Sampson Handley, and the method of spread to which he has given the name permeation

is shown to be a most important factor in the dissemination of the disease. This process has been studied particularly in connexion with cancer of the breast, but the conclusions arrived at may be referred to other organs also (*See* Vol. II, pp. 62-5.)

Invasion of lymphatic glands.—The process of permeation takes place in the medium-sized and smaller lymphatic vessels, as in these the lymph-stream is slow and feeble. When a column of cancer cells grows along a small lymphatic vessel in the direction of the stream, it will ultimately enter a large vessel in which the current is stronger. Cells become detached from the head of the column and are carried away to a lymphatic gland. When the method by which an afferent lymphatic vessel enters a gland is noted, it will

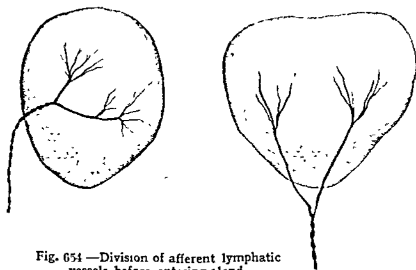


Fig. 654 —Division of afferent lymphatic vessels before entering gland.

be seen that it frequently breaks up into two or three branches which enter the peripheral lymph sinus separately (Fig 654); the terminal branches are each of them narrower than the vessel itself, and a cancerous embolus may be trapped at the point of division (Plate III, Fig 1). Here the cells proliferate and spread into the peripheral lymph sinus In other cases cells are carried directly into the gland spaces. In studying the method of spread to lymphatic glands the normal anatomical relationship of the affected organ to the lymphatic system must be remembered. Lymphatic vessels arising in any tissue are not all intercepted by the nearest group of glands, many evade the first set and enter glands of a more distant group, and vessels may be seen running directly to glands lying at a great distance from their origin (Fig. 655). It is evident that an embolus arising from the lymphatic plexus in the affected organ may be carried

directly to a gland lying close to the primary growth or to one at a distance, and one group of glands is just as likely to be affected as another, even in the early stages of the disease. This was well seen in a case of carcinoma of the colon in which the state of the glands was investigated (Fig. 656). The growth was a small one, encircling the gut in the upper part of the sigmoid flexure. To the inner side of the growth lay a small gland the size of a pea, soft, and apparently healthy; on the uppermost sigmoid artery, just below the lower pole of the kidney, there lay another gland, of the intermediate group, hard, yellow, and adherent to the peritoneum; a third gland lay on the outer side of the inferior mesenteric artery just below the origin of the left colic artery, and was soft and normal in appearance. No other glands were found in the vicinity of the tumour or along the vessel supplying the part involved. Serial sections of the glands and of the tissues of the mesocolon between the growth and the glands were cut. The primary tumour was an adeno-carcinoma. The paracolic gland was riddled with minute masses of growth; the intermediate gland was converted into a mass of tumour tissue, the ordinary gland tissue being seen only in places; the main group gland, which was so placed in the microtome that the upper end was cut first, showed no trace of growth until the extreme lower end was reached, where, in the entering end of a vessel, a plug of cancer cells was found. The tissue of the mesocolon along the course of the lymphatic vessels presented no evidence of disease. In this case, with a comparatively small growth in the colon, infec-

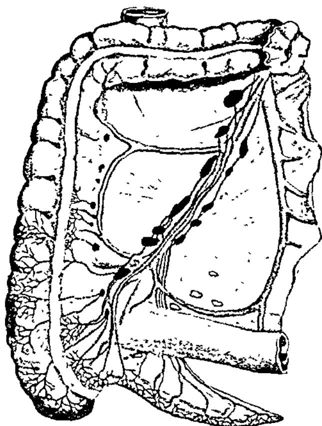


Fig. 655.—Lymphatics of cæcum and appendix.

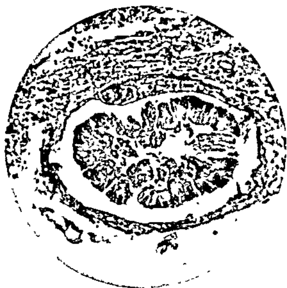


Fig 1 —Cancer embolus arrested in afferent vessel close to gland



Fig. 2 —Axillary gland from case of encephaloid mammary cancer showing cancerous masses without fibrosis

PLATE III.

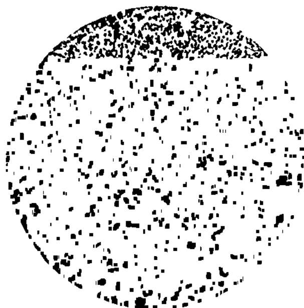


Fig 1 — Colloid epithelioma in lymphatic gland

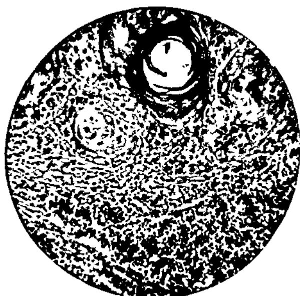


Fig 2 — Squamous carcinoma in lymphatic gland.

PLATE 112.

tion had already reached glands of the paracolic, intermediate, and main groups, and growth was most advanced in the intermediate gland. The glands had become affected by a process of embolism, and not by permeation of the lymphatic vessels in the mesocolon.

Any or all of the primary glands—those receiving direct vessels from the organ in question—may be attacked, and there are no means of determining at what stage this process begins.

The rapidity and extent of the invasion of lymphatic glands vary considerably, according to the situation of the primary tumour. In cancer of the stomach the glands are quickly and widely attacked; in epithelioma of the lip, glands may escape invasion for a considerable time. It cannot possibly be said of any malignant growth, however early, that it has not yet produced metastases in glands, and this fact has a most important bearing on the treatment of carcinoma.

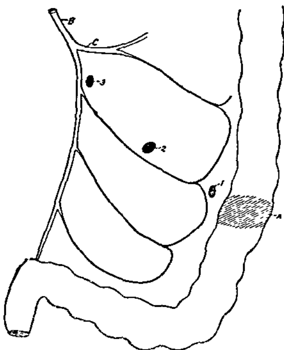


Fig. 656.—Infected lymphatic glands in case of carcinoma of colon.

A, growth; *B*, inferior mesenteric artery; *C*, left colic artery; *1*, paracolic gland; *2*, intermediate gland; *3*, main group gland.

A glandular growth is always of the same nature as the primary tumour (Plate 112), and, indeed, sometimes shows a more accurate picture of the histological characters of the growth than the primary lesion itself. The cancer cells invade the intraglandular network, spreading first in the peripheral lymph sinus, then between the follicles, eventually destroying the whole tissue of the gland. In cases where the primary tumour is ulcerated and infective material is carried to the glands, a simple periadenitis may occur, fixing neighbouring glands together, but as the cancerous process increases it spreads through the capsule of the gland and infiltrates fascia, muscle, vessels, and nerves, causing firm fixation of the glands to one another and to the structures around.

It is possible that cancer cells are occasionally destroyed in lymphatic glands; as a rule, however, the course of the affection is one of steady advancement. The whole gland becomes infiltrated with growth which penetrates the capsule and invades the surrounding structures. In time the fascia and skin over the glands become involved and ultimately necrose, giving rise to a profuse bloody discharge which is frequently offensive. The growth may fungate through the opening in the skin, or extensive ulceration may spread from the aperture. Free and ultimately fatal hæmorrhage from this cause is common in malignant disease of the glands of the neck. The pressure of the enlarged glands on vessels, nerves, or organs is the cause of serious symptoms: œdema and cyanosis occur, and severe neuralgic pain Pressure on the trachea may be so extreme as to necessitate tracheotomy, and the œsophagus may become so obstructed as to cause inability to swallow.

An interesting form of glandular disease is met with in some advanced cases of abdominal cancer—viz. a *supraclavicular adenopathy.* This condition most frequently results from cancer of the stomach, though it may follow any growth which produces metastases in the lumbar glands; it has been seen, for instance, after carcinoma of the testis. It appears at an advanced stage of the disease. Usually first observed as one or more small mobile glands in the left posterior triangle of the neck, lying under cover of the clavicle, it ultimately forms a large, deeply fixed tumour in the supraclavicular fossa. Sometimes the condition is bilateral, and sometimes it is followed by the enlargement of other glands in the neck or of the axillary glands. It appears that the adenopathy is caused by cancerous emboli carried in the lymph-stream of the thoracic duct, and in many cases the wall of the duct itself is found to be infiltrated with growth. In other cases the affection appears to have reached the supraclavicular glands by a gradual spread through the lumbar and mediastinal glands. A supraclavicular enlargement should always be looked for in cases of abdominal cancer, and its presence is, of course, a contra-indication to any attempt at radical operative treatment of the primary disease.

Diagnosis.—It is frequently very difficult to determine the malignancy or otherwise of a mass of enlarged glands in any part of the body. When the glands are hard and nodular, firmly fixed to one another and to neighbouring structures, the diagnosis is simple, and this is particularly the case when a primary growth is detected. In the early stages of malignant disease it is another matter. Glands may be comparatively soft, discrete, and freely movable. A very careful and thorough search, in which no instrumental aid to diagnosis can be neglected, must then be made for a possible primary growth.

If this is found, it is then to be determined whether the glandular enlargement is malignant or not. We know that ulcerated carcinoma may be associated with an inflammatory enlargement of lymphatic glands, and the enlargement may subside on the removal of the primary tumour. But the subsidence of the enlargement is, as a rule, merely temporary, and the glands in the majority of cases begin to increase in size again and show definite signs of malignancy. Any enlarged gland associated with a primary carcinoma must be regarded as containing the elements of malignancy. Even though a primary growth is unaccompanied by an enlargement of glands, it is impossible to say with any certainty that invasion of the glands has not already commenced. It is true that there are many instances of recovery from malignant disease after the removal of the primary tumour when no operation on the glands has been performed, and clearly there must be a period in the growth of every cancer when the disease is localized to its seat of origin. But we have no means of determining the limits of this period, and the onset and extent of the invasion of lymphatic vessels and glands is necessarily a matter of conjecture. In practice we must regard every case of cancer as one in which the lymphatic glands may already be affected.

Treatment.—It has been seen that cancer spreads beyond its obvious growing edge by permeation along small lymphatic vessels, and that local recurrences after operation are very frequently due to failure in the complete removal of the permeated lymphatic vessels around the primary growth As there are no means of recognizing the extent to which permeation has spread in any given case, surgeons are reduced to excising as much tissue as experience has shown to be necessary. In the case of the breast, permeation extends most widely in the fascial lymphatics, and extensive excision of the fascia is practised. In abdominal organs the omenta and mesenteries are known to be invaded, and these tissues are now more widely excised than was formerly the custom. Generally the tendency of present-day surgery is in the direction of a wider local excision of cancer, with the object of removing the permeated lymphatic vessels.

The great improvement which has taken place during recent years in the results of operations for cancer is largely due to the more adequate removal of diseased lymphatic glands. In some regions of the body, particularly the larynx, glandular invasion is, as a rule, a late manifestation of cancer, and in the early stages of the disease a purely local operation may suffice. But this cannot be predicted with certainty. It may be impossible for the surgeon to determine at the time of operation whether a growth has given rise to gland infection or not, and those glands which are likely to be invaded should be extirpated. The primary glands—those receiving direct

lymphatic vessels from the diseased organ—will be the first to be infected by cancerous emboli carried to them by their afferent vessels, and they must be removed whenever possible.

The importance of exact knowledge of the distribution of the lymphatic vessels and glands cannot be over-estimated. In dealing with cancer in any part of the body the surgeon should have in his mind the exact course of the lymphatic vessels and the position of the glands to which the vessels run. His object should be not to remove the individual glands, but to outline and separate from the surrounding structures a mass of tissue containing the primary growth, all the primary glands and the vessels running to them. The mass of tissue so delineated will necessarily include many secondary glands which receive efferent vessels from primary glands, and not direct vessels from the seat of growth, and the greater the number of these secondary glands that can be removed the better. But it is practically impossible to remove all the secondary glands of any organ in the body, and, indeed, in many situations it is impossible to remove all the primary glands. In most cases it is desirable to remove the lymphatic vessels intervening between the growth and the glands. It was at one time thought that in glandular carcinoma cancerous emboli detached from the primary cancer were frequently arrested at various points in the course of the lymphatic vessels, but that this rarely happened in the case of an epithelioma. However, it seems that the nodules found at a distance from a primary growth —e g between the breast and the axillary glands—are not due to the arrest of cancerous emboli in lymphatic vessels, but are the result of permeation of the smaller lymphatics and of the partial failure of the destructive process of perilymphatic fibrosis. (Plate 111, Fig. 2) There is no evidence, in the case either of glandular or of epithelial cancer, that cancerous emboli habitually become arrested in the lymphatic vessels, except at the point where these vessels enter the glands; when the lymph-vessels are filled with cancer cells it is by the gradual growth of cancer cells along the lumen. It is, nevertheless, very desirable to remove the lymphatic vessels running between the growth and the glands, and to remove them with the tissues in which they lie, for division of a permeated vessel may allow cancer cells to escape into the wound and produce a recurrence. Even if the divided lymphatic vessel is not permeated the pressure and traction on the primary growth during its removal may dislodge cancer cells which may be carried along the vessel into the wound.

The ideal operation for cancer consists in the removal *en masse* of the primary growth, the permeated lymphatic plexus around, the primary lymphatic glands, as many secondary glands as possible, the vessels connecting the growth and the glands, and the tissues

in which the vessels lie. Unfortunately, the ideal operation is rarely possible. In some organs all the primary glands cannot be removed —e.g. in the case of the breast some lymphatic vessels run directly to the glands of the internal mammary chain; and it is impossible to remove all the primary glands connected with a carcinoma of the stomach. In some cases a cancer may lie on the watershed of two lymphatic areas, e g. an epithelioma of the frænum of the tongue; in this case epitheliomatous cells may be carried to the submaxillary and deep cervical glands of both sides of the neck. The same may be said of epithelioma of the penis or scrotum, and of cancer in many other parts. The removal of two separate sets of lymphatic glands becomes in some situations an operation of great gravity. It may have to be done in two or even three sittings, and there is much difficulty in inducing patients to submit. In some situations—e.g. the rectum—the removal of glands with the primary growth is necessarily a very partial and incomplete process; many of the glands receiving lymph from the rectum are comparatively inaccessible Latterly the removal of the lumbar lymphatic glands has been practised in cases of malignant disease of the testicle. The early involvement of glands which occurs in this disease, the number and situation of the primary glands, and the inaccessibility of the majority of the secondary glands, together with the fact that recurrence has taken place in most of the cases operated on up to the present time, render it unlikely that the extension of the operation of castration will improve the prognosis of malignant disease of the testicle.

It is not always possible to remove the tissues that contain the lymphatic vessels connecting the growth and the glands. In epithelioma of the tongue or lip the growth and glands may be removed at separate sittings, or if this is done at the same time the glands are removed first, the wound closed and protected, and the growth excised. The object is to avoid infection of the large wound in the neck, and this advantage appears to outweigh any possible disadvantage in leaving portions of the lymphatic vessels.

The ideal operation is, as a matter of fact, rarely possible; the surgeon can only aim at it in the hope that, even if some cancer cells are left behind, the defensive powers of the tissue cells may be able to deal with them, or that postoperative X-ray treatment may destroy them.

When glandular invasion is evidently present a decision as to the feasibility and advisability of excision of the glands is often a matter of great difficulty. Where the glands form a large mass fixed to one another and to surrounding structures, or where there is evidence of involvement of vessels, nerves, or viscera, operative treatment is rarely practicable. It should be remembered that a gland in which

malignant disease is advanced is in much the same position as a primary growth. There is permeation of the lymphatic vessels around it, and it may have given rise to embolic invasion of any glands receiving vessels from it. When one or two glands—e.g. of the upper deep cervical group—are markedly affected, even fixed to the sterno-mastoid muscle, it may be worth while operating if the glands around are not enlarged. But if such a glandular mass is associated with even a moderate enlargement of surrounding glands, operative treatment is rarely advisable, as many other glands which are not yet palpable will be invaded.

Little can be done for inoperable secondary malignant glandular disease. If there is a primary growth, or a recurrence is present, every effort should be made to keep this as clean as possible, in the hope that secondary infection and necrosis of the glands may be avoided. Sometimes a certain amount of retardation of the growth may be observed under the X-rays or radium, but treatment on these lines is as yet in its infancy, and so far is disappointing. Such palliative operations as tracheotomy and gastrostomy may become necessary. In the case of the cervical glands death is frequently due to hæmorrhage. For this complication no operative interference is advisable; *morphia should not be withheld.*

INJURIES AND AFFECTIONS OF THE THORACIC DUCT

Injuries

The thoracic duct is occasionally wounded during operations for the removal of tumours or enlarged glands at the root of the neck. The accident may be manifest at the time from the escape of a quantity of clear or milky fluid in the depths of the wound. Careful inspection in a good light will reveal the wounded duct, which may be completely or only partially divided, and from which chyle may be seen to escape in jets. The thoracic duct generally terminates by several branches which open separately into the internal jugular and subclavian veins, and rarely by a single trunk. In the majority of cases ligature of the divided duct will not interfere with the circulation of chyle. The proximal end of the divided duct should be seized and ligatured, it is not necessary to tie the distal end, as reflux is prevented by the presence of valves at the termination of the duct.

If a single duct is unfortunately wounded, ligature should *still be the* method of closure, as there are sufficient connexions between the lymphatic channels and the venous system to carry on the circulation. It is not necessary to endeavour to suture the duct.

Sometimes a wound of the thoracic duct is not recognized at the time; [illegible] wound and forms a fluctuating [illegible] lymphorrhagia. The discharge [illegible] ral condition of the patient is seriously affected and death may occur from inanition, particularly when the accident is accompanied by infection of the wound. If the effusion of chyle is recognized before the wound has given way it should be treated by pressure applied above the clavicle. If lymphorrhagia occurs the wound

should be opened up and firmly packed from the bottom. It is rarely necessary to ligature or suture the duct, or to apply forceps to the cut end.

Rupture of the thoracic duct has occurred with fracture of the spine, particularly when this has taken place through the 10th dorsal vertebra, chylo-thorax or chylous ascites resulting. A rare accident is rupture of the intrathoracic portion of the duct, with chylo-thorax, following contusions or crushing of the chest. The chylous nature of the effusion will be recognized by exploration, and some cases have recovered after repeated tappings. An effusion of chyle into the retroperitoneal tissues has occurred as a result of a cart-wheel passing over the abdomen. In one case, laparotomy, drainage of the retroperitoneal effusion, and firm packing resulted in recovery.

Rupture of the duct may also occur as a consequence of obstruction and distension from the pressure of tumours.

Diseases

It must frequently happen that the thoracic duct is the channel whereby infectious and neoplastic elements are conveyed to the blood-stream, though actual disease of the duct itself is rare. In some few cases, after acute abdominal affections, the thoracic duct has been found inflamed and distended with pus

Letulle has described a case of cæcal tuberculosis in which the receptaculum chyli was obliterated by masses of caseous tubercle, and the thoracic duct infiltrated with nodules.

Obstruction and dilatation of the duct occur also in filariasis, and sometimes in tuberculosis.

Malignant disease of the thoracic duct may be present secondarily to a visceral carcinoma. *It most frequently occurs in advanced cases of carcinoma* of the stomach, and is usually accompanied by a supraclavicular adenopathy. The duct may be affected throughout its whole extent, forming an indurated moniliform cord, or nodules of growth may be met with at intervals. There is more or less complete obstruction to the flow of lymph which finds its way into the blood-stream through other channels.

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thyroid body of the adult. In the middle line of the pharynx, at the ventral end of the 1st or mandibular arch, and from the floor of the 1st cleft, a rounded body is developed known as the tuberculum impar, from which develops that portion of the tongue which lies in front of the line of circumvallate papillæ, and behind this is a V-shaped groove bounded on either side by the fused ventral portions of the 2nd and 3rd arches. From the apex of this V a diverticulum is developed which bifurcates and ultimately forms the mesial portion of the thyroid gland, its posterior part sometimes marked by a distinct process of the gland called the pyramid.

INJURIES OF THE NECK

CUT THROAT

This injury is usually deliberately inflicted, either suicidally or homicidally. It is very difficult to distinguish with certainty between the two, but, as a general rule, a homicidal cut throat is a more severe injury than a suicidal; it has been stated that an incision which involves the ligaments of the spinal column or notches the bones is always homicidal, but exceptions have been found even to this rule. The incision is usually made from left to right in the case of a right-handed suicide or murderer; in the latter case the attack is usually from behind, the assailant's hand occupying much the same position as that which his victim's would occupy were the wound self-inflicted. The line of the incision usually extends downwards and to the right, and, as a rule, is deepest towards the termination. When the wound is inflicted by a left-handed person or by a right-handed assailant attacking from the front the direction of the wound may run from right to left. These wounds are usually inflicted with a very sharp instrument, such as a razor; and when not self-inflicted they are usually fatal. In nearly all cases the head is extended upon the spine and drawn forcibly backwards, a position in which the great vessels of the neck are carried backwards behind the trachea. A homicidal wound is usually inflicted with such force that the position of the vessels does not save them from injury, and in this case death from hæmorrhage is almost immediate. In suicides, on the other hand, a very large number of cases occur in which only a trivial wound is inflicted, the greater vessels of the neck escaping entirely.

Practically every structure in the neck has been divided in these injuries; the larynx has been divided, the floor of the mouth has been opened up, and in some cases the victim's head has been found practically severed from the body.

Treatment.—The medico-legal aspect of these injuries is, of course, important, and the surgeon must observe accurately all details of possible legal interest. The first point in the treatment is the temporary arrest of hæmorrhage; this is usually not difficult,

inasmuch as, unless the carotids are divided—in which case the wound is inevitably fatal—probably only superficial vessels are bleeding. Then measures should be taken to counteract the shock, which is often severe in these cases. As soon as the patient has rallied the wound should be investigated more deliberately, all bleeding vessels ligatured, and the wound disinfected. The anatomical structure of the neck should then be restored as far as possible, divided ends of muscles being carefully brought together. The trachea can in some cases be sutured completely, but it may occasionally be wiser, especially if the wound is irregular and jagged, to draw the parts together as far as possible and then to perform a laryngotomy, so as to prevent subcutaneous emphysema, and to obviate any risk from œdema of the glottis: the tube can be left out after about forty-eight hours; a drainage-tube is put into one angle of the wound, the skin sutured, and an ordinary surgical dressing applied. The patient should be kept propped up in bed with the head forward so as to take tension off the wound and allow free play to the respiratory muscles. An excited or suicidal patient may need sedatives and sometimes restraint to prevent him from tearing off the dressings and reopening the wound. When the œsophagus has been injured—a rare accident in non-fatal cases—the patient should be fed per rectum for the first few days.

STABS IN THE NECK

In these injuries the lesion is similar to that met with in cut throat, but the wound is not so extensive. Death is usually caused by a wound of the carotid or the jugular vein, but in one case the vertebral artery was found completely cut across at the point where it passes over the transverse process of the 7th cervical vertebra. In some cases an extensive wound of the skin is produced by a stab with a cutting instrument, the edge of which divides the tissues from *within outwards.*

Treatment.—This is on the lines laid down above, but in these cases it is often necessary to enlarge the wound in order to deal satisfactorily with the injuries to the deeper structures and to ensure thorough cleansing.

CYSTIC TUMOURS OF THE NECK

These may be tabulated as follows: (1) Aneurysms, (2) blood cysts, (3) false cysts produced by the liquefaction of inflammatory swellings or new growths, (4) cysts connected with the salivary glands, (5) cysts of the thyroid gland, (6) lymphatic cysts—cystic hygroma, (7) parasitic cysts, (8) cutaneous cysts—sebaceous cysts, (9) dermoids, (10) congenital cysts developed in relationship with

branchial clefts or the thyro-glossal duct. The majority of these are described in their appropriate sections; the remainder must be considered here.

DERMOIDS [1]

Fusion of the two lateral halves of the neck may be imperfect, and, as a result, portions of the superficial epithelium become cut off from the surface and form cystic swellings. Those produced in this manner always occur in the middle line, most commonly in the region of the hyoid bone. They are usually small, but occasionally they extend upwards beneath the jaw and project into the floor of the mouth. Their structure is that of dermoids elsewhere; that is to say, they are lined with stratified epithelium, the inner layers of which undergo keratinization and are shed into the lumen of the cyst.

Hairs, glands, and other cutaneous appendages occasionally occur. The cysts contain a soft, pulpy material resembling inspissated pus, but consisting very largely of shed epithelium and the secretions of the glandular elements in their wall. Unless secondary inflammation is present, these cysts are painless and freely movable both on the skin and underlying tissues.

Diagnosis.—A dermoid cyst in the middle line of the neck must be differentiated from an enlarged gland; this is seldom difficult, as enlarged glands in the middle line are usually situated immediately beneath the symphysis of the lower jaw—a situation in which dermoids are uncommon. The source of infection in such glands is usually manifest on the lower lip or the chin. The history of the appearance of the swelling will of itself generally clear up the diagnosis, the dermoid being always congenital, and the gland of comparatively recent origin. It may happen, however, that the dermoid cyst has not been noticed until a short time before the patient applied for treatment, and the diagnosis must then be made on the physical characters of the tumour. *Sebaceous cysts* are often confounded with dermoids, but the differentiation should not be difficult, inasmuch as a sebaceous cyst is a tumour of the skin itself and always retains its connexion with it, while a dermoid is always subcutaneous. Further, in a sebaceous cyst it is generally possible to see the mouth of the gland from which it is developed. Sebaceous cysts, moreover, are uncommon in early life. From *cysts of the thyro-glossal tract* dermoids may be differentiated by their relationship to the hyoid bone. The dermoid cyst is always superficial to the structure, whereas a distension of the upper part of the thyro-glossal tract has a deep connexion with the surface of the hyoid

[1] *See also* Vol. I., p. 631, and Vol. II., pp. 208–12.

bone. Moreover, thyro-glossal cysts microscopically show a lining of columnar ciliated epithelium. The synovial bursa so constantly present between the upper part of the thyro-hyoid membrane and the hyoid bone may be enlarged and cause a cystic swelling resembling the cysts of the thyro-glossal duct, from which it can only be differentiated by microscopical examination. Below the hyoid bone dermoids are uncommon, and their diagnosis is usually simple.

ABNORMALITIES IN THE COURSE OF THE THYRO-GLOSSAL TRACT

This structure is the remains of the diverticulum of the ventral wall of the pharynx, which grows backwards from the apex of the V-shaped groove behind the tuberculum impar, a point represented in the adult by the foramen cæcum, to form the isthmus of the thyroid. *Normally this structure* [illegible] sented by [illegible] amentous [illegible] *issue de*-rived from the thyro-hyoid muscle and called the levator glandulæ thyroideæ. Less commonly there may be persistence of the duct to form either cysts or a fistula, or *portions of thyroid tissue may be developed in its walls at* any point in its course, forming the median variety of accessory thyroids.

Lingual dermoids are described in Vol. I., p. 631, and Vol. II., pp. 208–12.

Lingual thyroids[1] are developed in thyroid tissue along the duct, and are subject to the same diseases as the thyroid itself (*see* Vol. II, p. 209).

Cervical Fistula: Thyro-Glossal Cysts[2]

Below the base of the tongue, persistence of the diverticulum from which the middle portion of the thyroid gland is developed may give rise to cysts. (Fig. 657.) These may rupture spontaneously or be incised by the surgeon, with a resultant fistula. The thyro-glossal cyst usually occurs as a small, rounded swelling in the region of the hyoid bone. Unless there has been secondary infection, the skin over the cyst is normal and is not attached to it at any part. The swelling is elastic and fluctuant. On its deeper surface the cyst appears to have intimate connexions with the hyoid bone, especially towards the lower border, it being usually possible to push the cyst downwards from the front of the body of the hyoid, even when this structure is overlapped by the cyst. These cysts, apart from their appearance, cause no inconvenience unless *suppuration occurs in them; but should* this happen, and the cyst rupture or be opened, a troublesome fistula may result. When the cyst is small the diagnosis may have to be made from dermoids, enlargements of the bursa beneath the hyoid, sebaceous cysts, and enlarged glands. This has been considered in connexion with dermoid cysts. When a sinus is present its size and direction may be *estimated* by radiography after injection of bismuth.

Treatment consists in a thorough extirpation of the cyst or sinus. This is often a matter of considerable difficulty, but unless the whole of the cyst wall is removed the condition rapidly recurs. The best incision is an almost transverse one with a slight convexity downwards. It is frequently

[1] Stirling, *Annals of Surg*, 1907, Part II.
[2] *See also* Vol. I., p. 631, and Vol. II., pp 210–12.

necessary to divide the hyoid; it may subsequently be reunited with fine silver wire. A sinus, if present, should be cauterized at its opening with pure carbolic acid, and excised together with an elliptical area of skin. If the sinus is in the neighbourhood of the hyoid the incision may be transverse, but if it is lower down in the neck a median longitudinal incision should be employed.

Less radical measures, such as scraping or the injection of irritants—for example, iodine and carbolic acid—are not to be recommended.

CYSTS AND FISTULÆ DERIVED FROM THE BRANCHIAL CLEFTS

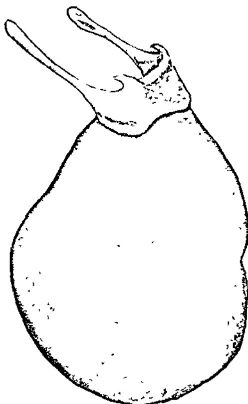


Fig. 657.—Large infrahyoid cyst.
(From a specimen in the Royal College of Surgeons Museum.)

Two varieties are reported—one lined with ciliated epithelium, and the other with stratified epithelium—and this suggests that two factors enter into their causation. In the first place, it is possible to conceive that the floor of a branchial cleft may become perforated and a sinus be produced leading from the pharynx to the exterior. At first it would be but a short canal, but with the development of the neck this would elongate, and if the openings became occluded a cyst would be formed, lying in the side of the neck. There is, however, the curious overlapping of the lower branchial arches by the upper, with the formation of the cervical sinus, which is thus merely a complicated sulcus lined by epiblast throughout and having no communication with the pharynx. It is possible that most of the cases of lateral cervical fistula are due to this cause rather than to the persistence of a branchial cleft. Cases have been described, however, in which there is an actual communication between the pharynx and the exterior. Cysts and fistulæ in this position are usually derived from the 2nd branchial cleft, and when fully developed open into the pharynx in the supratonsillar fossa, the representative in the normal adult of the 2nd branchial cleft. The fistulous tract passes outwards between the internal and external carotid arteries—a relationship of which the reason is obvious when the morphology of these vessels is considered, the external carotid being representative of the primitive ventral aortic trunk, while the commencement of the internal carotid represents the artery to the 3rd branchial arch which forms the posterior—that is to say, caudal—boundary of the 2nd branchial cleft.

They pass then over the loop of the superior laryngeal nerve, and, becoming subcutaneous along the anterior border of the sterno-mastoid, open on the surface towards the sternal end of this muscle. (Fig. 658.) A complete track of this nature is not common, but is valuable as showing the morphological significance of these fistulæ. A more common condition is that of a simple cyst situated under the anterior border of the sterno-mastoid muscle. These tumours are generally ovoid in shape, with a smooth surface, and, unless suppuration has occurred within them, they are movable in all directions. The cyst forms a single swelling—a point of some importance in the differential diagnosis between it and a cold abscess of the neck produced by the



Fig. 658.—Cervical fistula.

comparatively thin; on microscopical examination they are seen to consist of a lining epithelium, usually of the stratified squamous type, supported upon a connective-tissue basis containing a large amount of lymphoid tissue.

Fistulæ opening at the sternal end of the sterno-mastoid and extending a variable distance up into the neck are not uncommon. Except for the trouble caused by the constant discharge of the mucoid fluid from their orifice, they give rise to but little inconvenience unless suppuration occurs. They probably represent an imperfect closure of the cervical sinus.

Treatment.—The best treatment is the complete dissection of cyst wall or fistula from the structures of the neck In the case of the complete fistulous track this is an operation of considerable magnitude, and is best performed through a long incision along the anterior border of the sterno-mastoid muscle. The dissection should be commenced from below and carried upwards towards the wall of the pharynx, the sterno-mastoid being divided if necessary. The opening into the pharynx, which is usually smaller than the diameter of the fistula below, should be cut across, the mucous membrane pushed inwards into the pharynx, and the musculo-fascial wall of the pharynx sutured with catgut. The incision is closed after suture of the muscle, if this has been divided, and a drainage-tube put in at its lower

angle. Simple branchial cysts can be removed quite easily. The operation is best performed through a transverse incision with a slight curve whose convexity is towards the clavicle; the cyst wall is exposed and shelled out by a process of blunt dissection from the other structures of the neck.

In a few cases electrolysis with 5 to 10 ma. has destroyed the lining membrane of a sinus, which has then healed.

SOLID TUMOURS OF THE NECK

Many solid tumours are found in the neck, but the majority of these, including the commonest forms, have been described elsewhere in relationship to the diseases of the lymphatic glands, primary, or secondary to disease elsewhere, or in the sections devoted to certain organs in the neck, such as the thyroid gland (pp. 214 and 218).

LIPOMA [1]

Lipomas are not uncommon either as the ordinary encapsuled tumour, which differs in no way from the lipoma found in almost every other situation in the body, or as diffuse fatty tumours without definite margins, which form large collar-like swellings around the neck.[2]

TUMOURS OF THE CAROTID BODY

The carotid body is a small structure, 1–3 mm. in diameter, which lies at the junction of the internal and external carotid arteries. This point represents the ventral end of the 2nd branchial cleft; that is to say, it is the point at which the ventral aortic trunk, which is represented in the adult by the external carotid, gives off the artery to the 3rd branchial arch, a blood-vessel represented in adult life by the commencement of the internal carotid artery. It is probably not derived from the epithelium of the cleft, but from the strand of cells which ultimately develops into the sympathetic ganglia, in a manner similar to that in which the coccygeal body and the medulla of the suprarenal body are developed (Swale Vincent). In its early stage it is in intimate contact with the vessel wall, and is composed of epithelioid cells surrounding tufts of blood-vessels whose arrangement resembles that of the glomeruli of the kidney. The tumours of this body are either (1) simple non-malignant peritheliomas, which are highly vascular, do not recur after their removal, and do not give rise to metastases; or (2) highly malignant growths which have been named "potato-like tumours" by Jonathan Hutchinson. Tumours of this latter group consist of a highly cellular stroma with strands of epithelium forming alveoli of different sizes running through it. The cells themselves have

[1] *See also* Vol. I., pp. 387–91. [2] *See* Vol. I., pp. 390–2.

large reticulate nuclei with relatively abundant cytoplasm. Some of the cells are very much larger than the average, and have been described as giant cells; their nucleus, however, remains single. In contradistinction to the simple tumours of this gland there are very few blood-vessels in the stroma. Macroscopically, the tumours are hard and dense, with a slightly granular, greyish, moist surface on section, resembling, in fact, the cut surface of a potato. When the tumour is of any size there are usually roundish patches of necrosis.

Clinically, these tumours occur as swellings under the upper third of the sterno-mastoid; they are often bilateral. They are stony-hard, nodular, and almost immediately involve the arteries with which they are in contact, so that mobility along the line of the vessels is lost almost from the first. They do not move on deglutition, and are not accompanied by enlarged lymphatic glands The skin over them in the early stages is unaffected, but the sterno-mastoid muscle is early involved.

Treatment.—This is highly unsatisfactory, for although metastatic deposits do not occur early in the disease, and although the tumour may seem to be fixed only very slightly, it is found on operation to be almost impossible to remove these tumours without excising vital structures. Thus, in one case, portions of both internal and external carotids, the common carotid artery, the vagus and descendens hypoglossi nerves, and the internal jugular vein required excision. Death takes place usually either from cachexia or from hæmorrhage.

BRANCHIOGENETIC CANCER—BRANCHIOMA MALIGNUM[1]

Malignant growths originating in the walls of branchial cysts, or developing from vestigial remains of the branchial cleft which have remained dormant since fœtal life, form an interesting group of tumours of the neck.[2] Some doubt has been cast upon the accuracy of this etiological theory, but although some cases reported as bran- [illegible] may be merely malignant glands secondary to some [illegible] h has escaped detec- [illegible] evelop in the wall of a branchial cyst. A very large number of cases have been described, which fall into two great groups—viz. those developed from pre-

[1] See Vol. I., p. 560.

[2] [illegible]

carcinoma.

existing cysts, and those developed from vestigial remains of the branchial clefts. In the first group the structure of the tumour is that of a squamous-celled epithelioma with well-developed cell nests; in the second, the structure of the tumour closely resembles the mixed tumours in the parotid and submaxillary glands, which are generally recognized to be endotheliomas. There seems no good reason for excluding many of the tumours described under the term branchiogenetic cancer from the latter group.

Veau has described a case, under the name "branchioma malignum," in which the epithelial cells were arranged in plexiform strands, grouped around the blood-vessels in a manner very suggestive of an endothelioma; in places the tumour had undergone myxomatous degeneration, and nodules of cartilage were also present. Although the author comes to the conclusion that the tumour in his case was not an endothelioma, the careful drawings which he gives of its histological characters leave little doubt that it ought to be included among these tumours. At first sight it might seem illogical to ascribe to a common cause tumours so diverse in structure, but when it is remembered that the wall of a branchial cleft consists not merely of a layer of epithelium, but also contains connective tissue and a well-developed layer of lymphoid tissue, it is not surprising that more than one variety of tumour can be produced from it. These tumours occur in adult life, usually between the ages of 50 and 60, and are almost confined to males, only about 2 per cent. occurring in females. They commence as small, rounded tumours at the upper part of the neck, lying between the greater cornu of the hyoid bone and the angle of the jaw. The tumour enlarges and becomes ovoid, its long axis lying along the anterior border of the sterno-mastoid muscle. The surface of the tumour is at first smooth, but later on irregular nodules may form, which are connected with the main mass by a pedicle. The rate of growth varies, being at first slow, but ultimately extremely rapid, so that an enormous mass may be produced, invading the parotid region above and extending backwards across the posterior triangle beneath the edge of the trapezius muscle, crossing the middle line in front, and reaching the clavicle below, or even penetrating into the mediastinum. With increase in growth the consistency of the tumour alters; at first hard, it ultimately breaks down in its interior to form false cysts which may be mistaken for abscesses. The mobility of the tumour in its earliest stages is complete, but these growths soon involve the carotid sheath and become adherent to the jugular vein, so that, although their mobility from side to side may still be unimpaired, movement along the axis of the vessels is prevented. The skin is affected late, but the sterno-mastoid is invaded comparatively early.

Metastasis in the surrounding *lymphatic glands is not common*, and generalized infection is exceptional. In the later stages of disease the skin ulcerates and a typical malignant ulcer is formed. Death occurs from general cachexia or from hæmorrhage. During the enlargement of the tumour pressure symptoms occur similar to those produced by secondary carcinoma, such as paralysis of the vocal cords, dyspnœa from pressure upon the trachea, pain in the distribution of the cervical and brachial plexus, and dysphagia. The growth may project into the mouth within the ramus of the jaw, but in this situation it rarely ulcerates; it may, however, implicate the pharynx from behind, perforating this structure and giving rise to a malignant ulcer.

Diagnosis.—These tumours present clinically very slight differences from secondary malignant glands. However, owing to early adhesions to the carotid sheath, they soon become *immobile in a vertical direction*, and, further, *in the early stage the smooth surface* of the tumour differs from the nodular mass produced by the fusion of a number of infected glands. The diagnosis, however, must be made by a process of exclusion; this is so difficult that some authors have considered that these cases are secondary to small malignant growths of the naso-pharynx or pharynx which have evaded detection. Such cases undoubtedly occur, and must be eliminated as far as possible by a careful search of the pharynx, the fauces, tongue, œsophagus, nasal fossæ, and abdominal viscera, and also the testis, before the diagnosis can be maintained. Even when a primary source has been eliminated there still remain certain tumours of the neck which must be differentiated. Of these the most important are primary sarcoma of the lymphatic glands (from which in the later stages the diagnosis may be impossible before operation), endothelioma of the carotid body, and tumours of accessory thyroids. From carotid tumours diagnosis may be difficult before operation, but when the tumour is exposed the constant situation of the carotid tumour at the bifurcation of the artery, and its intimate association with this structure, differentiate it sharply from branchial cancer, which involves the vein *long before the artery. Accessory thyroids* occur sometimes in the same position, and carcinoma of these structures can only be differentiated by microscopical examination.

Treatment.—This consists in a radical extirpation of the growth, but the results are highly unsatisfactory, and recurrence is almost inevitable. These growths must be considered as among the most malignant tumours found in the body.

THE THYROID GLAND

Anatomy.—This ductless gland (Fig. 659) weighs about an ounce, and consists of two lateral lobes united by an isthmus lying over the 2nd and 3rd

tracheal rings. From the isthmus a conical process, containing thyroid tissue in its lower parts and fibrous and occasionally muscular tissue in its upper part, runs upwards towards the hyoid bone. A section across the isthmus and the lateral lobes shows that the organ embraces the trachea for about three-quarters of the circumference, coming posteriorly into close connexion with the œsophagus. The carotid sheath lies posteriorly and to the outer side of the gland. A distinct sheath of fascia forms a capsule to the gland, and posteriorly is connected intimately with the cricoid cartilage; in this way a fascial sling is formed by which the thyroid is held in intimate contact with the larynx and trachea.

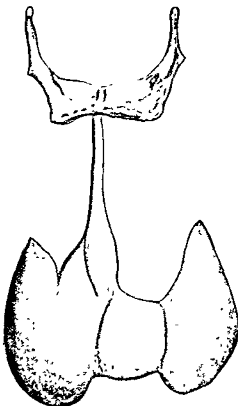


Fig. 659.—The thyroid gland.
(Royal College of Surgeons Museum)

The blood supply is very free. At the upper part of each lateral lobe the large superior thyroid artery enters the gland, and each lower pole is supplied towards its posterior surface by the inferior thyroid artery. There is also a fifth vessel, the thyroidea ima branch of the innominate. The veins, too, are extremely numerous, and exhibit great variations in their distribution: the superior and middle thyroid veins open into the internal jugular, the superior vein accompanying the superior thyroid artery; the inferior thyroid veins form a plexus in front of the trachea, ultimately discharging into the innominate veins. Both arteries and veins intercommunicate very freely beneath the capsule of the gland, and only comparatively small vessels actually penetrate the gland substance. A specially constant anastomosis between the superior and inferior thyroid arteries is found on the posterior surface of the gland; this vessel is important, since it is in close relationship with the parathyroid bodies The lymphatics are connected with the glands behind the sternum rather than with those along the course of the great vessels of the neck

In structure the thyroid gland consists of a number of closed vesicles, lined by cuboidal cells between which smaller cells—reserve cells—are interposed. In these vesicles there is found a peculiar glairy fluid (colloid), and often some detached epithelial cells and blood-corpuscles. The secretion of the gland is conveyed to the general circulation by means of the veins. An active principle, iodothyrin, which contains iodine, has been isolated from the colloid.

The thyroid gland presents many anatomical variations; thus the isthmus may be completely absent, the two lateral lobes being quite distinct.

frequently it is united to the right lobe; and in rare cases it is bifid, the divided lower ends of the lobe uniting the two lateral halves of the thyroid.

Accessory thyroids.—In the course of the development of the thyroid gland accessory masses of thyroid tissue are formed, detached from the main mass; these occur along the line extending upwards and backwards from the upper pole of the gland, downwards from the inferior pole, and upwards and inwards along the line of the pyramidal lobe. Isolated masses of thyroid tissue are also found in the substance of the tongue, where they are developed probably in relationship to the thyro-glossal duct, and within the larynx. A false accessory thyroid is sometimes produced by a pedunculated portion of the gland.

Functions of the thyroid.—The exact rôle of the thyroid gland is imperfectly understood, but it is fairly certain that it is capable of responding to demands made upon it by other organs in the body, and in toxic affections it may undergo enlargement. If the intoxication is transient the enlargement passes away and the gland resumes its normal size and structure, but if the intoxication persists the enlargement may become permanent, and a change that was at its commencement advantageous to the individual becomes a positive source of discomfort and even of danger.

In certain cases of enlargement of the gland, such as that which sometimes occurs at puberty, no intoxicating agent can be demonstrated. The enlargement in exophthalmic goitre and "functional hyperplasia" leading to hyperthyroidism will be referred to later.

Atrophy of the gland (due either to a fibrosis leading to shrinkage of the whole organ, or to disease which diminishes the number of actively secreting cells although sometimes enlarging the organ), non-development of the gland, or removal of a large part of the organ produces the conditions of **cretinism** and **myxœdema.** Cretinism is a condition of mental incompetence which is found in children whose thyroids are under-developed, or in whom the presence of a goitre has led to a functional hypoplasia of the gland. The individual is stunted in growth, with rough, coarse features and extremely poor mental development, retaining up to adult life the habits of childhood In *myxœdema* all the functions of the body are sluggish, and in addition to this there is a large development of subcutaneous fat which gives the patient a characteristic bloated appearance The pulse is slow, the digestion is impaired, and the patient constipated; the skin is dry and harsh, stiff and thickened, the complexion pinky yellow, and the hair is usually lost.

Enlargement of the thyroid is known as **goitre**, a term which is applied loosely to all varieties of enlargement. Various forms of goitre have been described without any distinct reference to strict

pathological classification. Thus such terms as *endemic*, *sporadic*, and *epidemic goitre* refer only to the incidence of the disease; *acute goitre* refers merely to the rapidity of growth; *suffocating goitre*, *substernal*, *intrathoracic*, *retrotracheal*, and *retro-œsophageal goitre* are self-explanatory terms. Enlargement of the thyroid may be classified as—(1) enlargement for physiological reasons (simple hyperplasia); (2) diffuse parenchymatous enlargement; (3) simple adenoma of the gland, solid or cystic; (4) malignant disease; (5) inflammatory conditions, acute or chronic; (6) cysts not in connexion with tumours (parasitic cysts); (7) the enlargement of exophthalmic goitre. It is very much more common in females than in males.

SIMPLE HYPERPLASIA OF THE THYROID

This condition is only trivial, and pressure symptoms are rarely present. If the cause can be discovered it should, of course, be removed if possible. Often the cases get well spontaneously; if this does not occur, small doses of iodide of potassium or thyroid extract frequently do good. It is possible that these substances meet the demand for an excessive amount of thyroid secretion, and hence by removing the need for increased glandular activity cause the hyperplasia to disappear. In some cases a permanent enlargement of the gland, usually of the diffuse parenchymatous variety, may follow.

DIFFUSE ADENOMATOUS HYPERTROPHY (PARENCHYMATOUS GOITRE)

In this affection the whole gland is enlarged, owing partly to an increase in its cellular constituents, and partly to an increase in the amount of colloid material in the vesicles. It is not uncommon to find this condition associated with adenomas. The disease commences usually in early adult life, but is occasionally found in children, and in its later stages symptoms of exophthalmic goitre may develop. The tumour produced varies considerably in size and shape. Though it usually preserves the horseshoe-shaped outline of the normal gland the isthmus may be so much increased in bulk that this appearance is lost. The surface of the tumour is coarsely granular, moderately firm in consistency, and, although handling may cause dyspnœa, the tumour itself is not tender. Unless fixed by its mere bulk or by prolongations into the thorax, it is freely movable upon the other structures of the neck. It retains the anatomical relations of the normal gland to a large extent, the increase in size taking place within the gland capsule, and the structures which lie outside this are displaced rather than overlapped. If the sterno-mastoids are made tense the tumour can be felt to be passing outwards beneath them, displacing the carotid arteries backwards and outwards. The attachment of the thyroid gland to the cricoid cartilage is retained, and the tumour moves with the larynx on swallowing. When the tumour

is of such size that the muscles which elevate the larynx are too weak to draw the whole tumour upwards, there is a tilting forward of the tumour on deglutition. The lower border of the tumour can usually be made out quite distinctly above the clavicle, but in some cases the tumour passes down behind the sternum and the 1st rib into the thorax, and there may be a patch of dullness over the manubrium sterni. The larynx and trachea in a pure parenchymatous goitre are not much altered in position, but if adenomas are present they may be displaced to one side. Pulsation may be observed in

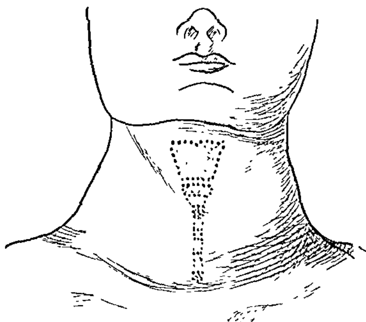


Fig. 660.—Diagram showing median position of the larynx and trachea in parenchymatous goitre, and severe lateral compression.

these tumours, transmitted from the carotids, or it may be produced by enlargement of the thyroid arteries.

Symptoms.—These are mainly pressure symptoms due to mechanical interference with the structures of the neck. The most important is dyspnœa. The trachea is kept patent by a number of rings of cartilage which are capable of supporting a very considerable pressure provided that this is applied uniformly; when, however, there is a lateral pressure sufficient to overcome the convexity of these rings, and to reduce the lumen of the trachea to a flattened space, a very slight increase in the lateral pressure will obliterate the lumen completely. In parenchymatous goitre, although the trachea is nearly surrounded by the gland, the pressure is almost exclusively lateral (Fig. 660)—a point which is of importance as

explaining the unsatisfactory results obtained by simple division of the isthmus for the relief of dyspnœa. In a well-marked case of tracheal compression the trachea is extremely flattened, with a sharp anterior border—a condition known as "scabbard-shaped trachea" (Fig. 661). When the enlargement has extended into the rigid inlet of the thorax, the pressure effects are even more severe. The dyspnœa may be exaggerated by any swelling of the mucous membrane which further narrows the already diminished tracheal lumen, or by abductor paralysis of the larynx which may occur, although rarely, in parenchymatous goitres. Swallowing is rarely interfered with.



Fig. 661.—"Scabbard" trachea.
(From a specimen in the Royal College of Surgeons Museum.)

On section the tumour exudes a large quantity of colloid material; it has a translucent appearance resembling tissue which has been cleared with clove oil for microscopical examination. The fibrous stroma is in consequence more apparent than that of the normal gland. The vessels are usually much dilated, but this dilatation is almost confined to the capsule and the tissue immediately beneath it; there is no great vascularity of the gland substance On microscopical examination the tissue presents no very marked deviation from the normal, except as regards the size of the vesicles (Fig. 662). These are very unequal in size, the larger ones forming small cysts which are visible to the naked eye, but which rarely attain a diameter of more than a few millimetres. Larger cysts are occasionally found, but these are due to the liquefaction of adenomas, and will be referred to later.

Treatment.—In the early stages of the disease the goitre sometimes disappears spontaneously, especially when its appearance has been associated with some definite change in the patient's environment. Return to the previous surroundings will often effect a cure. This factor should always be borne in mind in commencing the treatment of such cases. Iodides, iodine, and thyroid extract are sometimes of value, but only in the early stages, when it may be presumed that the hyperplasia is being produced by a call from other tissues for increased thyroid secretion. Unless this treatment causes manifest

improvement in two to three weeks, it should be discontinued. In many cases but little inconvenience is caused by the tumour; there is an increased storage of thyroid secretion, but the amount passed into the circulation may be quite normal. In these circumstances the tumour may be left alone, careful watch being kept for symptoms of hyperthyroidism and pressure. If pressure symptoms come on, or if the size of the goitre is such that the slightest constriction of the neck—for example, lightly grasping the front and sides with the hand—causes respiratory distress, a portion of the gland should be removed, generally one lobe, or one lobe and the isthmus. Mere division of

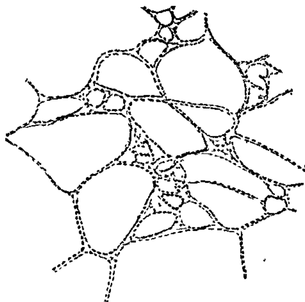


Fig. 662.—Section of a parenchymatous goitre.

the isthmus is practically of no value; the trouble is caused by the lateral lobes, which are pressed together by the muscles at the sides of the neck and the fascia, and not held together by the isthmus. In extreme cases both lobes have been removed and the isthmus left. No absolute rules can be given as to the exact portion of the gland which must be removed, but, speaking generally, an amount sufficient to relieve the pressure must be removed, enough gland being left for the requirements of the body. Injury to the parathyroids should be avoided.

ADENOMA OF THE THYROID[1]

This occurs either in a gland which is otherwise normal, or in one which is already the seat of parenchymatous enlargement. Two

[1] *See also* Vol. I., pp. 467–9.

types of adenoma are found—(1) the fœtal adenoma, the structure of which resembles the embryonic thyroid gland; and (2) the cyst adenoma, which resembles the structure of a parenchymatous goitre. Both types may be the subjects of cystic and other degenerations.

Symptoms.—These resemble those of parenchymatous goitre; that is to say, there is the inconvenience of the tumour, which may

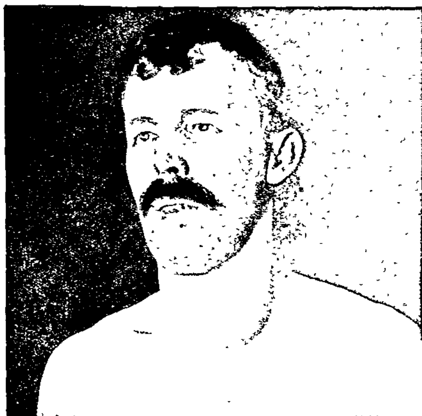


Fig. 663.—Adenoma of thyroid, front view.

be very large, and there are pressure symptoms. An adenoma of the thyroid does not, therefore, necessarily cause any symptoms whatever. As a rule, the pressure symptoms are not so severe as those produced by parenchymatous goitre, the tumours tending to grow forwards and project from the surface between the bellies of the sterno-mastoids. (Figs. 663, 664.) The adenomas are usually multiple, so that the thyroid gland may assume very diverse shapes; they may be distributed equally through the gland, or may be confined to one lobe. It is this irregularity in the shape of the

gland which affords the main diagnostic difference from parenchymatous goitre. The vessels of the gland are often dilated both on the surface and in the capsule of the adenoma. The carotid arteries are displaced backwards and outwards; the trachea is very commonly displaced from the middle line, carrying with it the larynx (Fig. 665), and the displacement may be accompanied by some



Fig. 664.—Adenoma of thyroid, side view.

compression. On examining the trachea from the outside this displacement is usually quite readily made out, and if a direct-vision bronchoscope is passed beyond the vocal cord it is often possible to see actual bulging of the wall of the trachea into its lumen.

The pressure symptoms vary in severity according to the situation of the tumour. A large one situated in the isthmus may cause considerable deformity (Fig. 666), and may even produce a swelling which hangs down over the front of the chest wall without producing any

pressure symptoms whatever, whereas a much smaller adenoma which has become incarcerated within the superior aperture of the thorax may cause the gravest or even fatal pressure symptoms. Cases have occurred also in which the adenoma has been situated towards the back of the gland, causing serious pressure upon the œsophagus. The most dangerous form of pressure symptoms is produced by hæmorrhage into an adenoma situated wholly or partly within the thorax, and the rapid increase in the size of the tumour may suffocate the patient before any assistance can be given. It is often

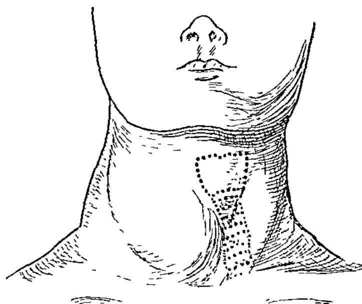


Fig. 665.—Diagram showing trachea and larynx in adenoma of thyroid. There is displacement without much compression.

difficult to distinguish a solid from a cystic adenoma, unless the cyst is large enough to fluctuate definitely. Even then the enlargement may turn out to be a large, soft, solid tumour. When the cyst is calcified, typical "parchment crackling" may be obtained on pressure.

The **pathology** both of the fœtal type, chiefly found in children and adolescents, and of the common cyst adenoma, is described elsewhere (Vol I, p. 467).

Treatment.—Medical treatment in these cases is useless and if the adenoma is causing any interference with respiration, or if it is situated in such a position that a sudden increase in its bulk is likely to cause pressure symptoms, it should be removed. This

applies also to cysts. The tapping of thyroid cysts, followed by the injection of irritants, is to be condemned. In the first place, it is impossible to be certain that the trocar will not wound one of the vessels in the cyst wall, leading to a severe hæmorrhage within the capsule of the cyst, which might cause the gravest pressure symptoms. In the second place, some suppuration seems to be essential to a satisfactory obliteration of the cavity—a process accompanied by such risks as to make it hardly justifiable.



Fig. 666.—Adenoma of central portion of thyroid.

MALIGNANT DISEASE OF THE THYROID

The thyroid is one of the most unfavourable situations in the body for malignant disease, whether carcinoma (Fig. 667) or sarcoma. This is due not so much to early metastatic deposits as to the early penetration of the capsule and involvement of the very important surrounding structures, to the difficulty in diagnosis until the neighbouring structures are implicated, and to the arduous and dangerous nature of the operative removal.

Diagnosis.—Enlargement of lymphatic glands is not a particularly early accompaniment of this disease, and even when these are affected it is usually in the deep glands along the trachea and the glands in the mediastinum that secondary deposits are found, so

that their detection before operation is practically impossible. The superficial glands of the neck are involved late or not at all.

Malignancy is often a complication of simple thyroid enlargements (Figs. 668, 669), and this again tends to obscure the diagnosis. The diagnostic symptoms are as follows :—

1. **Rate of growth.**—When a lobe of a thyroid begins to enlarge very rapidly, or when a nodule in an already enlarged thyroid takes



Fig. 667.—Carcinoma of thyroid. Note diffuse and irregular enlargement of neck.

on an accelerated enlargement, malignant disease should be suspected and operation insisted upon.

2. **Consistency.**—Malignant disease is usually harder than other types of thyroid enlargement, and the presence of an unusually firm nodule in the gland should excite suspicion It is true that adenomas occasionally become calcified, but the error in mistaking this condition for malignant disease can be readily eliminated by a skiagram. The chronic interstitial inflammation described later (p. 221) resembles malignant disease extremely closely, and in most of the cases which have been reported the nature of the tumour has only been finally settled by operation and subsequent histological investigation.

3. **Involvement of surrounding structures.**—This is produced by the direct extension of the growth beyond the confines of its

capsule, and, as already indicated, justifies the gravest prognosis. The trachea is very soon implicated, but it is difficult in the living subject to demonstrate this in its early stages. The larynx and trachea are in ordinary circumstances comparatively mobile from side to side, and even in a case of a simple goitre the fascial relations are such that the tumour moves up and down on the trachea only to a



Fig. 668.—Carcinoma of thyroid. The primary growth, presenting, in considerable part, the appearance of an adenoma.

(Museum of University College Hospital Medical School.)

very limited extent. It follows, then, that a malignant growth may have infiltrated the trachea to a considerable degree but may have retained a considerable amount of lateral mobility. The surgeon should therefore endeavour to ascertain whether the tumour moves on the trachea or merely with the trachea. Two forms of this tracheal involvement are seen in the accompanying figures. In Fig 670, from an early case in which a malignant growth has super-

vened upon a thyroid already enlarged and containing several small cysts, there is a distinct flattening of the trachea, part of which, it



Fig. 669.—Local recurrence of the carcinoma of thyroid shown in Fig. 668. Note pressure on larynx, involvement of surrounding tissues, and extensive breaking down.

(*Museum of University College Hospital Medical School.*)

is true, may be accounted for by the previous disease of the thyroid. In the second type, shown in Fig. 671, the lumen of the trachea has

jerk upwards of the upper lid occurs when the patient is directed either to look straight in front of him or to move the eyes suddenly upwards. Very rarely the lower lid lags behind in a similar manner during the upward movement of the eyeball. Von Graefe's sign, like the exophthalmos, may be unilateral.

Tachycardia and palpitation are among the earliest and most constant signs of the disease. At first they are intermittent, but in

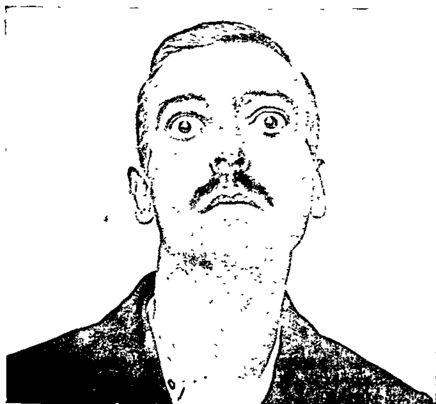


Fig. 674.—Severe exophthalmic goitre in a man.

the later stages they are constantly present, and are exaggerated when the patient is excited in any way. The increased pulse-rate is accompanied by well-marked pulsation of all the arteries, due to the violent action of the heart.

Enlargement of the thyroid is a very variable symptom in the early stages of the disease, but it is practically always present when the disease is well developed. In a typical case the enlargement is moderate; that is to say, about two or three times the normal bulk of the gland. The thyroid is at first soft, but often becomes hard as the disease progresses; well-marked pulsation is

usually present, *transmitted from the adjacent arteries of the neck* and a distinct systolic thrill can often be felt over the tumour. The enlargement is generally uniform (Fig. 675), but occasionally, as already mentioned, only half the gland is enlarged, and unilateral goitre may be accompanied by unilateral exophthalmos. Inasmuch as the symptoms of hyperthyroidism *may occur* in the course of other kinds of thyroid enlargement, many different forms of goitre are met with in the disease.

Muscular tremors.—These may be either jerky movements or a fine muscular tremor, especially manifest when the patient's hands *are stretched stiffly out in front of him.*

These cardinal symptoms represent what may be called a typical



Fig. 675.—Exophthalmic goitre: two aspects of same case, to show degree of enlargement of thyroid gland.

case, and, although such cases are quite common, atypical cases, in which some of these symptoms are absent, are often met with. Among **other symptoms** are pyrexia, gastro-intestinal disturbances, *flushing of the skin, profuse perspirations, glycosuria, and albuminuria.* The general health is usually affected; the metabolic rate is increased; the patient loses appetite, becomes anæmic and loses weight, and in women the menstrual functions are irregular or suppressed. Hysterical symptoms of all kinds, such as anæsthesias and paralyses, are common. *The mental condition may be altered*: the patient is restless, irritable, and unable to do any work which requires concentration or effort; there may be mild hallucinations or even serious mental disease. This *generally takes* the form of mania, running an acute and rapidly fatal course, but occasionally subsiding *into chronic* insanity.

Course of the disease.—The onset is generally gradual, but it may be comparatively sudden. It is usually preceded by some

severe mental or physical strain, and a combination of both of these factors is especially liable to produce the disease. In such circumstances quite typical cases occur, but patients are often met with in whom a condition occurs differing from the fully developed disease in not possessing the classical symptoms, but which is probably a mild form of it. The patients notice that they are easily tired, and are exhausted after muscular exertion which would not affect them under normal conditions. In addition, they are subject to fits of irritability and depression from quite insignificant causes; there is a varying degree of tachycardia, and the normal functions of the alimentary canal are interfered with, usually producing constipation. The thyroid is sometimes moderately and uniformly enlarged, the increase in bulk just making the gland definitely palpable; it is soft and smooth. Exophthalmos is usually absent. These cases of mild thyroidism are by no means uncommon, and in all cases of ill-health following a physical and emotional strain, especially in young women, the possibility of its existence must be considered.

The disease may, however, develop quite acutely. For example, Solbrig has recorded the case of a boy of 8 whose mother had exophthalmic goitre. A trivial disappointment at school was followed by profuse sweating and palpitation; the next day the thyroid was enlarged, and there was a certain degree of exophthalmos. The whole attack passed off completely in ten days. The disease may follow an injury. Thus, Léniez records the case of a cavalry lieutenant who was thrown from his horse and fell on his head. There was slight concussion, but this rapidly passed off, and no ill effects of the head injury remained. A month later the right lobe of the thyroid enlarged, the eyes became prominent, and the pulse rose to 110. In addition, there were muscular tremors and weakness, especially in the legs, headache, insomnia, flushing of the skin, and mental irritability. The general nutrition suffered considerably, and the patient lost 20 kg. in weight. Under medical treatment he ultimately made a good recovery. It is a matter of some dispute whether these cases of sudden onset of exophthalmic goitre are in reality rightly so considered. Although many have been reported, the percentage is small, and it has been suggested that in these patients the disease was already commencing insidiously, and that the onset of the symptoms was precipitated, rather than actually caused, by the accident.

The progress of the disease is varied. It may become chronic, or the patient may pass into a condition of acute toxæmia, the symptoms resembling those of malignant endocarditis, the temperature raised, the respiration quickened and laboured, the heart rapid and irregular, the tongue dry, and the patient suffering from nausea,

vomiting, and profuse diarrhœa. All these symptoms may come on without much enlargement of the thyroid or any marked exophthalmos. In connexion with the gastro-intestinal disturbance the liver is often enlarged, tender, and painful, delirium followed by stupor ensues, and the patient dies. In a few cases recovery takes place up to a certain point, and the patient passes into the chronic stage.

At this stage the exophthalmos and the goitre are more constantly present than in the earlier or than in the acute toxæmic stages, and the condition of the patient may remain without alteration for a considerable period, ultimately improving slowly either spontaneously or as the result of treatment, or increasing in severity. When recovery does not take place the goitre usually tends to become harder and diminish in size. The temperature is subnormal, and the patient loses weight. Anæmia of the chlorotic type is present, and increases in severity; there is usually some albuminuria or diabetes, which may be the cause of death. Intractable diarrhœa is an ominous sign. *Syncopal attacks occur, and may cause death. The mental condition* is sometimes profoundly affected, and the patient may die of acute mania. In some cases towards the termination of the disease there is a gain in weight, and a species of myxœdema supervenes. The patient is liable to develop acute thyroid toxæmia, ending fatally.

Pathology.—In a typical case the appearance of a thyroid gland is characteristic. The enlargement is uniform and the surface of the gland smooth or finely granulated, presenting none of the gross irregularities which are common in adenoma. On section the surface of the gland is homogeneous and has a peculiar dense, solid appearance; colloid material is either absent, or present to a very slight extent. The blood-vessels are not engorged, but, on the contrary, are smaller than those which would be found in a parenchymatous goitre of the same size. On microscopical examination the gland presents an extremely cellular appearance, resembling at first sight a carcinoma produced by an extensive increase in the secreting cells of the gland. The epithelium of the alveoli of the normal gland is thrown into a number of folds more or less completely filling up the lumen of the alveolus to the exclusion of the colloid. The cells lining the alveolus have a tendency to become columnar. This condition in an advanced case occurs throughout the gland, but in early cases it may be confined to one part of it. In addition to the characteristic appearance of Graves's disease, any of the histological features of other types of thyroid enlargement may be present. These are probably only accidental, the disease occurring in patients who are already the subjects of goitre and are probably more susceptible than normal individuals. The whole gland presents the appearance of being in a state of increased activity, the secretion

being passed on into the circulation as soon as it is formed, and not retained as colloid material in closed vesicles.

Coincident hyperplasia of the thymus is often found. Changes have been reported in both the central and the peripheral nervous system, but these are so inconstant and slight that they throw no light on the etiology of the disease. The amount of iodine found in the thyroid is usually diminished, probably due to the fact that it is passed into the secretion as soon as the iodine-containing substances are elaborated. The phenomenon of exophthalmos has been variously accounted for, and was at one time supposed to be due to an affection of Müller's muscle or to engorgement of the orbital veins. Although there may be some slight distension of these vessels it is probable that the main cause of the protrusion of the eyeballs is an increase in the amount of fatty tissue in the orbit. As much as half an ounce of fat has been removed post mortem from the back of the orbit. The eye itself is usually normal, except in cases where the lids fail to meet, when, as a consequence of exposure of the sclera, conjunctivitis and ulceration of the cornea may occur. In some cases, however, actual elongation of the eye itself, associated with myopia, has been recorded.

In the later stages of the disease the heart becomes dilated and the seat of fatty degeneration.

With the exception, therefore, of the increase in the active part of the thyroid gland, there are no constant changes to be found post mortem in this disease, and it is probable that the condition must be regarded as one in which a hyperplasia of the thyroid for physiological reasons has started a vicious circle leading to the production of a poisonous amount of the thyroid product. According to Rogers the soft goitres which are found so commonly in young girls should be considered as allied to the early stages of exophthalmic goitre, inasmuch as they are the expression of a thyroid hyperplasia which is brought about by the increased demand made upon the gland by the active processes of growth and development in these patients. The gland in this case is more active than normal, but the activity of the epithelium is still insufficient to meet the demands of the body. This hypothesis is supported by the fact that thyroid feeding in such cases is extremely beneficial up to a certain point, but that beyond it this method of treatment may do harm.

Treatment.—Physical and emotional strains are the common causes of onset of this disease, and they also, when it has once developed, exaggerate the symptoms. The first indication, therefore, is rest and the elimination of any factors that disturb the patient's life. Under such treatment some cases recover. In the earliest stages iodides are of value, but their use must not be continued unless

marked improvement is obtained, and any increase in the symptoms is an indication for prompt cessation of the iodide treatment. Kocher strongly advocates the use of phosphates in these cases, given in the form of *sodium phosphate*, ½–2 drachms a day. A large number of other therapeutic measures have been suggested, all of which have supporters, and from all of which cures have been reported. It is very difficult to discriminate between these, especially as the results obtained by various observers differ. It must be remembered, however, that the disease sometimes disappears spontaneously; and there is so large a neurotic element in all cases that the effect of suggestion must always be borne in mind. Among the various remedial agents that have been favourably reported upon are *anti-thyroid serum*, prepared by injecting rabbits or sheep with the nucleo-protein and globulin of the human thyroid at intervals of five to seven days for several weeks; the *proteins of the thyroid gland*, either in combination or separately; *extract of pancreas, or the pancreatic nucleo-protein*; *adrenalin*; the milk of thyroidectomized goats, either fresh or in the dried form of *rodagen*. Statistics of recoveries under "medical" treatment have been collected, but these demonstrate little beyond the fact that some cases undoubtedly recover completely, or at any rate sufficiently to carry on their normal life without abnormal effort.

X-ray treatment is of distinct value in improving or curing both subjective and objective symptoms. The treatment requires the supervision of an expert radiologist, who must always bear in mind the possibility of an operation becoming necessary in the near future. In addition to the risk of sepsis which is introduced by an actual burn, skin which has been over-exposed to X-rays often heals badly, or actually sloughs, after it has been incised; moreover, the fibrosis caused in the connective tissues may add to the difficulties of any subsequent operation.

Surgical treatment.—In all but the slightest cases in which recovery takes place under medical treatment, the most potent factor in which is probably rest, operative interference holds out the most promise. Although it is a wise plan to commence treatment in all cases with a period of rest, during which medical treatment, either general or specific, may be adopted, operation must not be postponed too long, for it is in late cases that it is dangerous and the result unsatisfactory. The prolonged toxæmia has so damaged the patient's heart that recovery must always be imperfect; the nervous phenomena have persisted so long that the patient is unable to regain self-control; the orbit is so packed with fat that exophthalmos cannot disappear.

Operation was for a long time looked upon with disfavour on account

of the risk of death which is unquestionably present either during the operation or within the first few days, but this dread of operation has diminished considerably of late.

The operations for this disease are—(1) ligature of the arteries alone; (2) ligature of the arteries and veins; (3) extirpation of a portion of the gland.

The operation of excision of the cervical sympathetic chain, introduced by Jonnesco, is now seldom done.

Some surgeons deliberately omit to ligature the veins on the assumption that any interference with venous return leads to a congestion of the gland and an increased lymphatic flow, thereby precipitating symptoms of thyroidism. The venous anastomosis is, however, so free that when only one or two vessels are ligatured there is no objection to the inclusion of the veins in the ligature This operation should be carried out through a transverse incision at the level of the upper pole of the gland, and if both superior thyroid arteries are to be ligatured this can be done through the one incision. The general trend of opinion to-day is towards the abandonment of ligature of the arteries, the operation on the gland being performed straight away.

Postoperative complications.—In addition to the risks of the operation proper, and the risk of death in the course of it, analogous to that which occurs in cases of status lymphaticus, it sometimes happens that the patient dies of acute thyroid toxæmia in the first few days. This is not necessarily due to any interference with the gland, inasmuch as it has been observed to follow operations upon other parts of the body in cases of exophthalmic goitre If too much thyroid is removed, myxœdema may be produced; and a case has been recorded in which sclerodermia came on six weeks after hemithyroidectomy had been performed for Graves's disease

Results—These are increasingly encouraging, and it is no longer necessary to quote statistics to justify operation. Some surgeons attribute this to the employment of local anæsthesia, but the advantages of this procedure are by no means generally admitted for any but exceptional cases, and it is more probable that the improvement is due to the facts that cases are operated on earlier and not, as was formerly the rule, as a last resource, and that the importance of light handling of the gland during the operation is better understood.

OPERATIONS ON THE THYROID

The anæsthetic.—The anæsthetic problem in operations on the thyroid has aroused much discussion. As regards inhalation anæsthesia, chloroform, however skilfully given, is highly dangerous, and should be avoided altogether. Light ether anæsthesia is safer;

while gas and oxygen with a minimal amount of ether is probably the best of all.

Intratracheal insufflation anæsthesia, once established, is very satisfactory, but the deep anæsthesia necessary for the introduction of the cannula is highly undesirable.

Local anæsthesia is specially recommended by some in Graves's disease, but it is just these cases which bear the emotional strain the worst. To diminish this, the so-called combined method is sometimes employed, in which local anæsthesia is associated with the inhalation of nitrous oxide to produce sleep. Crile has attempted to save the emotional strain by administering the anæsthetic surreptitiously,

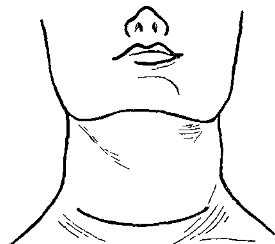


Fig. 676.—Incision for hemithyroidectomy.

giving a dummy inhalation daily as a part of the treatment, and on the day of the operation giving gas and so anæsthetizing the patient: or by giving rectal injections of plain oil, replacing this one day by an oil-ether mixture.

All these methods may be borne in mind for occasional use, but it is probably true that a light gas-oxygen-ether anæsthesia skilfully given will be found the best for most cases.

Removal of half the gland.—The gland is best exposed by a transverse incision across its front (Fig. 676), which may in some very extensive cases need to be prolonged upwards on the affected side. The platysma is divided at a slightly higher level, and reflected almost up to the hyoid bone (Fig. 677). The sterno-hyoid and sterno-thyroid muscles are either separated or divided close to their hyoid attachments. The vessels entering the upper pole of the gland are occluded and divided close to their point of entry into the capsule, and the freed upper pole is then drawn steadily downwards and forwards,

other vessels being caught and divided until the lower pole is brought into view. The inferior thyroid vessels are now secured; this is best accomplished by thrusting a pair of fine pressure forceps into the gland substance just where the vessel has disappeared, and repeating this manœuvre until the lower part of the gland is freed, leaving the extreme posterior pole in place, and thus avoiding any injury to the recurrent laryngeal nerve and the parathyroids. The gland can now be dislocated forwards into the neck and the isthmus divided. The depressors of the hyoid are sutured if they have been divided, the platysma is sutured, and the wound closed with a fine

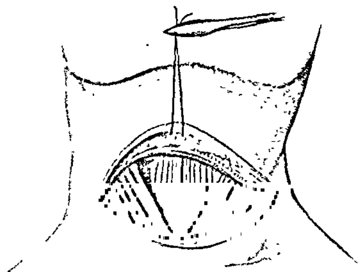


Fig. 677.—Excision of part of the thyroid gland. The skin and platysma have been divided, exposing the deep muscles, viz. the depressors of the hyoid in the middle line and the sterno-mastoid on either side.

horsehair suture and a fine round needle, a small drainage-tube being inserted into the middle of the wound. The temporary use of this tube is important in cases of exophthalmic goitre The tube can be removed after about forty-eight hours, and the stitches taken out in about a week. This operation for extirpation of half the thyroid is on the lines laid down by Halsted, its object being the preservation of the parathyroid arteries by securing the thyroid arteries after these vessels have been given off. It has sometimes been called the method of ultra-ligation Even if, as many surgeons maintain, precautions against injury of the parathyroids are unnecessary,[1] this method is

[1] Berry has performed operations for removal of goitre 1,338 times without encountering any sign of injury of the parathyroids.

of value, as it protects the recurrent laryngeal nerve from injury. If the retained half of the gland is very large and unsightly, it is often possible to remove the upper part of the remaining lobe and yet leave enough gland behind. This, however, is not often necessary, as, although the neck is rather unsightly immediately after the operation, the natural appearance is soon restored.

Sufficient thyroid tissue must be removed to cure the symptoms; in most cases removal of one lobe and the isthmus is sufficient, but sometimes a subsequent operation for the removal of part of the other lobe is required.

To avoid postoperative hyperthyroid reaction, gentleness of handling is essential; to remove escaping thyroid material, suprasternal drainage is necessary for twenty-four hours; Crile at present leaves the wound unsutured till the next morning.

Removal of the whole thyroid (for malignant disease).—Through a horseshoe-shaped incision across the thyroid, with limbs extending upwards on either side, the gland is thoroughly exposed, and the deep connexions of the growth are carefully examined. If it be confined to the thyroid, both superior thyroid arteries are divided between ligatures or clamps, the middle thyroid vein and inferior thyroid vessels are secured on one side, and the gland turned downwards and towards the opposite side, the thyroidea ima artery meantime being caught. As much as possible of the deeper fascia over the trachea and great vessels is removed, and the remaining inferior thyroid vessels and middle thyroid vein are divided and the gland removed. The sterno-thyroid and sterno-hyoid muscles are now repaired, and the wound drained and sutured.

If during the operation involvement of the trachea or œsophagus is found, recurrence is almost inevitable, even if portions of these tubes are removed.

Thyroid extract must be subsequently administered throughout life.

Enucleation of adenomas of the thyroid gland.—Exposure of the thyroid gland is effected by a slightly curved transverse incision with concavity upwards, but there is rarely any need for division of the depressors of the hyoid, as it is usually possible to draw these aside until the surface of the gland over the adenoma is exposed; the capsule is then incised, care being taken to avoid any especially prominent vessels. The gland substance is then torn through with a blunt dissector until the capsule of the adenoma is reached. This can be identified by its colour, which is usually dark bluish from the presence within the tumour of extravasated blood. It is important to recognize the exact point at which the adenoma is separated from the gland by a capsule, as it is only at this level that the tumour can be rapidly and easily shelled out. The enuclea-

tion is carried out either with the fingers or with some instrument such as that invented by Kocher for the purpose, vessels being clamped as soon as they are brought into view. Sometimes the cavity can be obliterated by passing deep sutures through the gland, and when this is possible it should be done. A drainage-tube is now passed into the cavity and brought out at one angle of the skin wound. If multiple adenomas are present the operation may be repeated in the case of each, or if they are confined to one lobe it may be simpler to do a hemithyroidectomy.

In very large adenomas or cysts the capsule of the tumour is sometimes fused with the capsule of the gland, and in these cases it is sometimes better not to make the incision directly over the swelling, but rather to one side through normal thyroid tissue. This enables the capsule of the gland to be more readily distinguished and facilitates the operation.

Tracheotomy should never be performed as a substitute for the removal of a lobe of the gland when dyspnœa is very marked. The operation is often extremely difficult, owing to the depth of the trachea and its small size—more difficult, often, than removal of half the gland. It must, however, be performed in some cases of malignant disease, and the only points to bear in mind are that it will be an extremely difficult operation, that it may be necessary actually to divide the growth in order to find the trachea, and that a long flexible tracheotomy tube should be at hand which can be passed down beyond the obstruction.

THE PARATHYROID GLANDS

Anatomy.—The first accurate description of these structures was given by Sandström, and Gley demonstrated that loss of their internal secretion was the cause of the tetany which was occasionally observed after extirpation of the thyroid. They are developed from the 3rd and 4th branchial recesses, independently of the thyroid. In man they are constantly found associated with this structure, but the association is more or less accidental, and in the lower animals it is not so constant. In the goat, for example, two are found in relationship with the thymus, a fact which probably accounts for the ability of these animals to bear removal of the whole thyroid exceptionally well. The variation in the positions of the parathyroid glands accounts for the discrepancies in the accounts given by experimenters of the effects of removing the thyroid and parathyroids, but it is now pretty generally accepted that excision of the thyroid gland leads to myxœdema, and that removal of the greater part of the parathyroid tissue leads to tetany, while complete extirpation is inevitably fatal. This is in opposition to the older view, which is still held by some authorities, that the parathyroids represent merely an undeveloped nodule of thyroid gland which is capable of developing into normal thyroid tissue and of performing its functions. (Fig. 678.)

The parathyroids are typically four in number, designated by Welch the

postero-superior and the antero-inferior pair. One or more are occasionally absent. They are about the size of a grain of rice, reddish or yellowish in colour, and are situated on the posterior surface of the thyroid gland, where they receive a vascular supply which is very large in comparison with their size. The parathyroid artery usually arises from the inferior thyroid artery, or from the anastomotic branch between the superior and inferior thyroid; occasionally the superior parathyroid is supplied from the superior thyroid artery. The artery to this gland does not anastomose with the vessels of the thyroid proper, there being always a distinct fibrous capsule separating the two, but the branch of the inferior thyroid from which the parathyroid artery is given off may receive a communicating branch from the œsophageal arteries; hence it is possible that the blood supply may remain intact even after ligature of all the main vessels going to the thyroid.

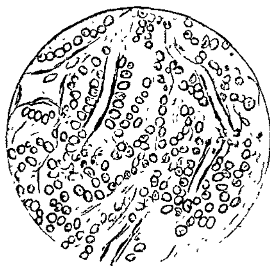


Fig. 678.—Section of parathyroid gland.

It is remarkable that an organ which seems to play so important a part in the economy is so little liable to disease, the only tumours that have been recorded being simple adenomatous enlargement. As a result of removing or injuring the parathyroids a remarkable train of symptoms occurs, which is well illustrated by a case reported by Pool. Three years previously the patient had had dyspnœa and dysphagia as a result of a large tumour in the region of the left lobe of the thyroid gland This was excised, and for a time the patient was quite well. Enlargement of the isthmus of the thyroid produced a recurrence of the symptoms, and it became necessary to remove this part of the organ. In the course of the operation the inferior artery was ligatured. In all probability, therefore, the left pair of parathyroids was removed at the first operation, and at the second the blood supply to the right pair was interfered with. The healing of the wound was uneventful, but on the fourth day tetanic contractures, accompanied by cramp-like pains, appeared in both hands; there were plantar flexion of the feet and twitching of the facial muscles; general spasms occurred also, sometimes affecting the muscles of respiration and causing a cyanosis, which was relieved by the administration of chloroform. When the muscles were quiescent the spasms could be brought on by stretching or irritat-

ing the corresponding nerves. Thus, by tapping the cheek over the facial nerve a spasm of the nerves of that side of the face could be produced, while bending the trunk upon the thighs evoked tonic plantar flexion of the foot. This patient ultimately recovered as a result of treatment, but the symptoms lasted more than a year.

Prophylaxis.—It is only in recent days that any attempt to preserve these organs in extirpating part of the thyroid has been made. When the operation is unilateral there is little risk of their being injured, but if one lobe and the isthmus are removed, or if both lobes are removed and the isthmus is left behind, there is a risk of injury to these structures; and Halsted has given directions by which this accident can be avoided. An outline of these precautions is given in connexion with the operation for thyroidectomy.

When *cachexia parathyroideopriva* develops, the best results have been obtained from the injection of the proteins of the parathyroids of oxen, either an emulsion of the whole gland or the nucleoprotein of this organ. If parathyroids can be obtained from a healthy individual they may be engrafted soon after death, preferably into the remains of the thyroid gland or into the sheath of the rectus. Calcium lactate, given either by mouth or by rectum, or injected intravenously, is reported to be of value.

THE THYMUS GLAND

This structure, situated mainly within the thorax, projects upwards into the neck for a variable distance; it attains its maximum development about the end of the second year, after which it gradually disappears. Its structure closely resembles that of a lymphatic gland, but it differs in containing epithelial cell nests known as Hassall's corpuscles.

No definite specific function of this gland has yet been ascertained. From its structure it seems reasonable to assume that it performs the same functions as the lymphatic glands, but there seems to be a *curious association between enlargement of the thymus* and sudden death, which has suggested to most observers that there is some causal relationship between the two. It is true that in these cases enlargement of the thymus is only a part of a generalized lymphatic enlargement, hence the term "status lymphaticus"; but enlargement of the gland is perhaps the most striking post-mortem feature. These cases of thymic death have attracted attention owing to the occurrence of death during the induction of anæsthesia; by some it has been assumed that the anæsthetic was directly responsible, and by others that the emotional disturbance of the operation was the most potent factor. It seems certain, at any rate, that there is a condition, occurring in children, in which sudden death is liable to follow any sudden strain, however trivial. (Plate

113) In contradistinction to these cases, patients in whom the thymus is known to be persistent or enlarged have been subjected to fairly severe operations with safety.

Whatever be the explanation of the cause of thymic death, it seems fairly certain that a simple mechanical one will not suffice. In the first place, evidence of pressure is entirely wanting. Cases do occur in which an enlarged thymus may cause pressure, but in these the train of symptoms is altogether different. In the second place, respiration continues after the heart has ceased to beat, and it is difficult to imagine any pressure within the superior aperture of the thorax which would affect the cardiac nerves and leave the air-passages intact.

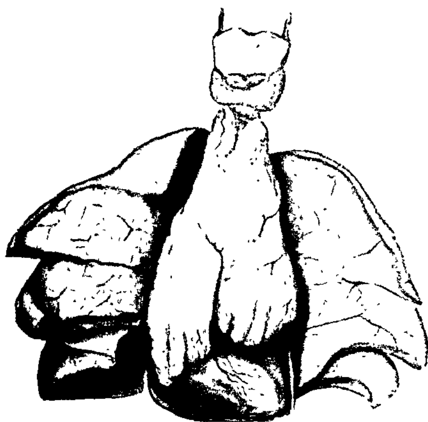
Simple hyperplasia of the gland may produce symptoms of dyspnœa. For example, Charles Mayo records a case in a male child 11 months old who had had dyspnœa from birth. The child was occasionally cyanosed and convulsed; he breathed best when the head was fully extended, there was an area of dullness about 1½ in. to the right and 1 in. to the left of the sternum, extending downwards to the level of the 3rd rib. A skiagram showed an opaque area corresponding in extent to the dullness. The diagnosis of enlarged thymus was made and one lobe of the gland removed. The operation was carried out through a transverse incision low down in the neck; the inner borders of the sterno-mastoid were divided and the sterno-hyoids cut across; the gland was then caught up with forceps, and by a little gentle traction, aided by blunt dissection, the right lobe was removed. A year afterwards the child was reported as doing well.

Hyperplasia of the gland is sometimes found in adults; it is stated that this occurs in practically every fatal case of exophthalmic goitre.

In addition to simple hyperplasia, many diseases of the thymus have been reported. Thus, it shares in the general enlargement of the lymphoid tissues in leukæmia and Hodgkin's disease. It may be the seat of a primary lympho-sarcoma. Abscesses and cysts are also known. Tubercle and syphilis affect the gland, but only as a part of a generalized infection.

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Thymus and other viscera of a boy aged 3, who was admitted under the author's care for a radical cure of hernia. The child had been in the hospital for a day or two, and was to all appearance a perfectly healthy boy. On the night of his death he went to sleep quite naturally, but about an hour afterwards he was heard to give a gasping cry and was found to be dead. No anæsthetic had been administered, and there was no evidence that the child had undergone any emotional disturbance beyond that of leaving his mother.

THE NOSE AND ACCESSORY SINUSES

By HAROLD BARWELL, M.B., F.R.C.S.

Inspection (Figs. 679–82).—Before examining with the speculum, inspect the orifices, observing any undue narrowness, any dislocation of the inner limb of the lower lateral cartilage or of the anterior end of the triangular cartilage, and any collapse of the alæ on

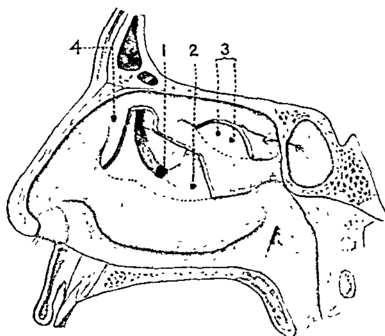


Fig. 679.—Outer wall of nose.

4, Agger nasi.

inspiration. Observe the breathing through the nose during quiet respiration, closing each nostril alternately with the pulp of the

thumb; if it be closed by compressing the ala, the opposite naris will be distorted. To examine the nasal passages a speculum is required; a good pattern should be capable of being introduced and held with one hand, should lift the nostril so as to afford a view along the floor of the nose, and should be comfortable to the patient. Thudichum's and Lennox Browne's are both excellent in these respects. They are held between the thumb and first two fingers of the left hand, while



Fig. 680.—The frontal sinuses.

On the right side the anterior wall and floor of the sinus have been removed and the ethmoidal region exposed by cutting away part of the nasal process of the superior maxilla The left sinus is far smaller than the right

the other fingers are placed firmly on the patient's forehead to control and steady the head.

On looking into the nose one sees first the inferior turbinal, a smooth, reddish-pink body with a bulbous anterior end; if it be not swollen, one should be able to see a little way under its outer concave side. Above and behind the inferior turbinal can be observed the middle turbinal, under the anterior end of which is seen the upper extremity of the hiatus semilunaris, bounded in front and below by the unciform process. The so-called olfactory slit between the septum and the middle turbinal is too narrow to allow a view into the superior meatus. In a wide nose, when adrenalin or cocaine has been thoroughly applied, it is possible to see the posterior wall

of the naso-pharynx, which moves on deglutition, the arching upper boundary of the choana, and, above, part of the anterior surface of the sphenoid; but a good view of the latter can usually only be obtained after removal of part of the middle turbinal body. The septum is very rarely perfectly straight, and no greater mistake can be made than to consider septal irregularities as pathological,



Fig. 681.—Method of examination.

unless they are causing symptoms. A slight rounded projection can generally be seen on the septum near the anterior end of the middle turbinal; this is sometimes called the "tubercle" of the septum, and marks the region where its mucosa is thickest and most vascular. The healthy nasal passages present numerous slight variations, and some experience is therefore needed to recognize a normal nose.

CONGENITAL MALFORMATIONS

Congenital malformations of the nose are all uncommon. Occasionally the tip of the nose presents a **central depression** which imparts to

it a bifid appearance. A **congenital stenosis** is sometimes present at the junction of the vestibule with the proper nasal cavity, an undue prominence of the plica vestibuli forming a tight band along the outer wall and floor of the nose; and more rarely a web of skin completely occludes the nostril in this situation. The **treatment** of these cases is difficult, for the stenosis tends to recur with great persistence. The web, if thin, should be thoroughly destroyed with the galvano-cautery; if thick, it should be cut away with a fine knife, and a splint of thick indiarubber introduced, and retained for two to three weeks.

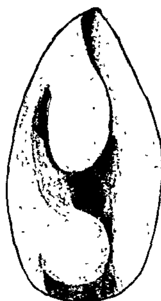


Fig. 682.—The normal naris.

Congenital occlusion of the posterior nares is also a rare condition, which may be bilateral, but usually affects only one side. The occluding diaphragm is situated just within the choana, and is generally formed by bone, which may be very thick and dense; it may, however, be partly or entirely fibrous, and sometimes presents a small perforation. Great discomfort results from accumulation of secretion which cannot be expelled by blowing; but unilateral occlusion, at any rate, does not appear to produce secondary effects on the ears. Defective development of the face and jaws of the corresponding side may be observed, but this is by no means always noticeable. **Treatment** consists in thorough removal, with chisel and punch-forceps, of the occluding diaphragm, together with enough of the posterior part of the septum nasi to prevent the formation of synechiæ; if this be thoroughly done, no splint or packing is required. The septum is often deflected towards the occluded side; in cases where this condition exists the anterior part of the septum should be resected submucously, and the posterior part should be completely removed at the same time.

INJURIES

Fractures and Dislocations

The structure most frequently broken is the triangular cartilage of the septum; the nasal bones are much less often fractured, the perpendicular plate of the ethmoid rarely, and the vomer practically never.

The septal cartilage is usually broken in one or other of two directions, either about a nearly vertical line far forward in the nose, or obliquely in a line parallel to and near the upper border of the vomer. In the first form the septal projection is situated at the narrowest part of the nares, and is therefore the more obstructive; the portion of the septum in front of the line of fracture is sometimes so deflected as to look almost directly forwards and to be very noticeable. The second form of fracture produces a ridge running from the floor of

the nose backwards and upwards, and forms one variety of the so-called septal spur. Very considerable thickening often results from a fracture, and so produces projecting bosses which obstruct both nostrils. When there is much deformity of the cartilage, its anterior end may be dislocated from between the inner limbs of the lower lateral cartilages and project into the nostril on the side corresponding to the concavity of the bent septum. Finally, the cartilage of the septum may be dislocated from its attachment to the vomer. This accident produces an oblique ridge upon one side, due to the lower edge of the cartilage, and a bony ridge upon the other, caused by the projection of the vomer.

The nasal bones may be smashed in and broken in any direction by great violence, but by far the commonest fracture is a transverse one separating the lower third of the nasal bone, which is the thinnest and least firmly supported. One nasal bone only is usually broken, and the fragment is generally much depressed, while the septal cartilage is also broken and displaced to the opposite side. The result is a very characteristic deformity. The depression of the broken fragment, small though this is, causes the crest of the nasal bridge to appear deflected to the opposite side, and the deformity is continued below by the displaced septal cartilage. In most cases the nose appears to curve to one side and to return towards the middle line at the tip.

Fracture of the perpendicular plate occurs in association with fracture of the nasal bones, but any marked displacement in this region is very uncommon. This fracture is usually the result of considerable violence, and is very likely to extend to the base of the skull in the anterior fossa.

Symptoms.—Almost all fractures of the nose are compound through the mucosa, and are associated with epistaxis; exceptionally, the blood forms a hæmatoma under the muco-periosteum of the septum. In spite of being compound, these fractures unite with remarkable rapidity, and septic infection is very rare. The epistaxis is often profuse, but is not long continued; in cases of fracture through the base of the skull into the nose there may be persistent oozing of blood, and also discharge of cerebro-spinal fluid and even of brain.

Treatment.—If there is external deformity the case should be treated as soon as possible. The septum can then be readily replaced, and depressed fragments of the nasal bones raised, with a broad septal forceps such as Moure's, or with sequestrum forceps the blades of which are covered with rubber tubing. It is then necessary to keep the fragments in position, but packing with gauze or wool is impossible, as it quickly becomes septic. The best material is a piece of pure rubber sheeting, which can be obtained in various

thicknesses, boiled before use, and cut to fit the nares after the shape shown in Fig. 683. It must be kept in for ten to fourteen days, which can readily be done if a mild antiseptic lotion is syringed twice a day with a fine nozzle along both sides of the splint.

The various external trusses and moulded splints are founded on the idea that the bridge is really, instead of only apparently, pushed over, and are quite ineffective in ordinary cases. In very bad cases of shattered and depressed fracture a good plan is to transfix the nasal bones with a stout pin and to pass a second pin through the cartilages at a lower level; the lower portion is then lifted up to the required position by a figure-of-eight twist of silk around the pins on either side. A piece of indiarubber may also be pushed over both ends of either pin to exert lateral pressure, or Ouston's special pin, provided with metal buttons, may be employed. The pins should be retained, if possible, for ten days.

Fig. 683.—Outline of rubber nasal splint.

If the fracture is restricted to the septum and there is no external deformity, it is sound practice to wait until the inflammation has subsided, and then to perform a submucous resection of the deviation, should there be sufficient nasal obstruction to demand it. This is less painful to the patient, and the great swelling which follows the injury makes it impossible to foretell how much obstruction will finally result

In cases of old fracture of the bridge the deformity is very difficult to correct; the best method is usually to divide the bones along the line of fracture with a fine chisel through an open incision, for aseptic wounds on the face leave little scarring. When the bridge has been completely smashed in, the nostrils become tilted forwards and a very unsightly deformity results. In such cases it is a good plan to graft in a portion of the patient's own costal cartilage, carefully cut to the required length and shape. For extensive destruction of the soft parts and skeleton of the external nose, ingenious plastic operations have been elaborated from the experience gained in the War; for these the reader is referred to special works.

Injection of paraffin wax into the subcutaneous tissue of the bridge of the nose is a useful method of improving the appearance in certain cases of old fracture, and also in cases of deformity due to syphilis

and to abscess of the septum. The wax should have a melting-point of about 115° F., and must be injected under the strictest aseptic precautions. It is difficult to use in the fluid state at the required temperature, though various devices have been invented to prevent it from solidifying in the needle. It is better to inject it in solid form with a pressure-syringe such as Mahu's. No anæsthetic is required; the wax is warmed to body temperature, the needle inserted from above downwards in the middle line, and the wax moulded as it is introduced. Adhesions which bind down the skin must, if present, be divided with a tenotome two days before.

HÆMATOMA OF THE SEPTUM

This is the result of injury, and is always associated with fracture of the septal cartilage. It is common enough in children, but decidedly rare in adults The swelling produced by the collection of blood beneath the muco-periosteum is always bilateral, and the contents of the swelling communicate through the fracture. Thus is produced a rounded fluctuating tumour projecting into both nostrils (Fig. 684) and covered by the normal mucous membrane The only affections which it resembles are abscess and gumma of the septum; the former may be distinguished by the signs of inflammation, and the latter by the history and concomitant lesions of syphilis.

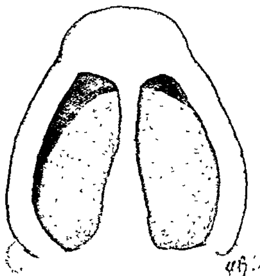


Fig. 684 —Hæmatoma of septum.

Treatment.—Although the effused blood is frequently absorbed in some three or four weeks, a good deal of thickening and consequent obstruction *is likely to remain. Secondly, suppuration is* very liable to ensue, and an abscess of the septum with its resulting deformity to occur. Thirdly, it is impossible to know how far the broken fragments are displaced within the blood-tumour. Fourthly, the swelling causes complete nasal obstruction while it remains, and is therefore very uncomfortable. For these reasons it is better to incise a hæmatoma, unless it is quite a small one, by cutting through the muco-periosteum under cocaine, to clear out

the clot with a spoon, and to keep the nose clean by syringing with a mild antiseptic lotion. If it be decided to leave the hæmatoma to become absorbed, it is most important to watch the patient daily, for on the first sign of inflammation the swelling must be opened and drained in order to prevent deformity of the bridge.

ABSCESS OF THE SEPTUM

This is always due to suppuration of a hæmatoma. The appearance is the same, with the addition of the signs of inflammation. If it be not opened at once, necrosis of the septal cartilage ensues, and the subsequent cicatricial contraction causes a sharp depression of the bridge immediately below the nasal bones. This deformity is only found when the cartilage is destroyed by necrosis, and is not only very unsightly but is generally ascribed by the public to syphilis, to which, indeed, it is most often due.

Treatment.—The abscess must be opened, syringed out, and freely drained immediately. A simple incision is not sufficient, for this quickly closes, and a drainage-tube can hardly be kept in position. It is best to remove a small portion of the abscess wall by clipping away part of the mucosa backwards from the incision with punch-forceps. The abscess and the nasal cavity must be regularly syringed out. If depression of the bridge occur, it should be treated by the subcutaneous injection of paraffin wax.

SYNECHIÆ

Synechiæ are sometimes seen connecting the septum and middle or inferior turbinal bodies. They may be due to any lesion which destroys the epithelium on both sides of the nasal passage, but most often they follow surgical interference and especially unskilful application of the cautery. They produce a variable degree of nasal obstruction depending on their size and position. The best practice is to wait until cicatricial contraction is complete, when a fleshy synechia will often be seen to have dwindled to a thin bridle. A fine band then merely requires division with a sharp knife, but a stout adhesion can only be cured by removing so much of the turbinal from which it springs that the parts no longer come into contact. Attempts to separate the cut surfaces by packing or splinting usually end in failure.

FOREIGN BODIES

Any kind of substance may be pushed into the nose, especially by children, or vomited matters may enter the posterior nares; and it is recorded that [illegible] entered the nose in this way and been removed. Maggots [illegible] of neglected suppuration and ozæna, [illegible] in this country. *Rhinoliths* are [illegible] the nasal secretion which form a con-

cretion around a small foreign body or a fragment of dried mucus as a nucleus. They vary much in size and consistency, are generally almond-shaped and rough on the surface, and have in rare instances been so large as to expand the bones of the face. Any body remaining long in the nose will become covered with this concretion

The **symptoms** are purulent nasal discharge, obstruction, and sometimes epistaxis, neuralgia, and epiphora. A unilateral purulent discharge in a child is nearly always due to a foreign body Maggots appear to cause very severe pain, profuse bloody discharge, abscess, cellulitis, and even meningitis. The object can generally be discovered without difficulty on careful probing, but has often produced ulceration and become covered by granulations. Skiagraphy is sometimes helpful in difficult cases.

Treatment.—The foreign body must be carefully removed, under inspection with a good light, by forceps, scoops, or hooks. This is facilitated by the use of cocaine and adrenalin to produce shrinking of the mucosa A general anæsthetic is necessary in children, except in the simplest cases, and then a finger in the naso-pharynx will assist the grasping of the body and prevent it from falling into the air-passages. A large rhinolith may require to be broken up by forceps before removal Maggots should be stupefied by chloroform vapour and dislodged by syringing with carbolic lotion.

ACUTE RHINITIS

Acute Catarrhal Rhinitis

Etiology.—This affection, which is part of a coryza or common cold, is doubtless an infective disease, and is produced not by one specific bacillus, but by any of several organisms, some of which are normally present in the throat and nose. Its etiology is therefore a question of the relative virulence of the organism and the susceptibility of the subject at the moment Virulence is increased by passage through a susceptible individual, and thus it is common to find that colds are imported into a household by a susceptible person, who "catches" them and infects the more resistant persons around him. Although chilling of the body lowers the resistance, a healthy open-air life is the best safeguard against colds. Of all things, a draught in a hot, ill-ventilated room most strongly predisposes to coryza.

Acute rhinitis is also a symptom of the infective fevers, especially influenza and measles. Among the organisms which have been shown to be causative are Friedländer's bacillus, the *Bacillus septus*, the *Bacillus influenzæ*, the *Micrococcus catarrhalis*, and the *Micrococcus paratetragenus*.

The **symptoms** are well known. There is first a feeling of dryness and discomfort in the nose or naso-pharynx, with malaise and with or without fever; then nasal obstruction with profuse watery discharge; and finally the discharge becomes muco-purulent. An ordinary cold usually lasts a fortnight, but the muco-purulent discharge may continue indefinitely in weakly subjects, or a chronic rhinitis may be set up by frequent attacks of coryza.

Complications.—The inflammation may cause acute sinusitis or otitis. In some patients it regularly extends down the throat and produces laryngitis, tracheitis, or bronchitis.

Treatment.—Few people will take time and trouble to treat a cold efficiently, and it must be acknowledged that treatment is often disappointing. Patients subject to bronchitis, and those in whom a cold interferes with work, such as singers and other professional voice-users, should submit to treatment. In the very earliest stage a cold can frequently be aborted by securing free diaphoresis. The patient should go to bed and be very warmly wrapped up, take a hot drink and 10 gr. of Dover's powder, quinine in two or three 5-gr. doses every two hours, or one or other of the various preparations of quinine. Cinnamon has lately been much recommended, and occasionally seems to do good if used in sufficiently large doses. Of local treatment, syringing with Dobell's solution (*see* p. 253), or normal saline, undoubtedly shortens the duration of the rhinorrhœa and prevents the discharge from becoming purulent, besides diminishing the discomfort. Some patients get relief from an oily spray containing menthol, eucalyptol, or similar drugs. Cocaine and adrenalin should on no account be used, for the temporary relief obtained is dearly bought by the increased congestion which follows. In those subject to coryza, much can be done by attention to general hygiene, exercise in the open air, warm absorbent clothing, and tepid or cold baths according to the response of the circulation. For prophylaxis both autogenous and stock vaccines are of value in many cases, though disappointing in some. An initial dose of stock vaccine will be made up somewhat as follows: *Micrococcus catarrhalis* 25 millions, *pneumococcus* 50 millions, *Bacillus influenzæ* 10 millions, *Staphylococcus longus* 10 millions, *Staphylococcus pyogenes aureus* 250 millions. A second injection of double this dose in ten days is usually sufficient; but in some cases a more prolonged course is necessary, the dose being again doubled, and repeated every six weeks through the winter. In general the inoculations should be given in the autumn.

Acute Purulent Rhinitis

Unless gonococcal in origin, this is not a clinical entity, for a true purulent nasal discharge either comes from an accessory sinus, or is due to some specific ulceration or to a foreign body.

Acute purulent rhinitis occurs in infants as the result of gonococcal infection at birth. The affection is accompanied by profuse bilateral discharge of pus, swelling of the deep cervical glands, and nasal obstruction which seriously interferes with suckling; the nostrils and upper lip become excoriated. The treatment consists in frequent cleansing of the nose with Dobell's solution (p. 253), and then painting

the mucosa of the middle and inferior meatus as thoroughly as possible with a 2-per-cent. solution of protargol in glycerine. The infant must be fed with a spoon if nasal obstruction be so marked that it can take neither the breast nor the bottle

Gonococcal rhinitis in the adult is exceedingly rare.

CHRONIC RHINITIS

Chronic Catarrhal Rhinitis

Etiology.—Simple chronic rhinitis is apparently apt to result from frequently recurring attacks of coryza, and a single severe cold may fail to clear up, and leave a condition of chronic catarrh. But some predisposing cause must be sought for to explain the persistence of the catarrh. These predisposing causes fall into four classes—namely, deficient resisting power, local irritation, auto-intoxication from the gastro-intestinal tract, and reflex vaso-motor disturbance. Clinically, therefore, we find chronic catarrh associated with anæmia and general ill-health, living in a stuffy or dusty atmosphere, excessive smoking, snuff-taking (which is not uncommon among clerks and shop-assistants who must not smoke during the day), dyspepsia, constipation, portal congestion, alcoholism, sexual excess, and masturbation. Mechanical nasal obstruction is an important factor in the maintenance of catarrhal rhinitis, and acts by preventing proper ventilation, allowing mucus to collect, and encouraging the growth of micro-organisms The presence of adenoids is the commonest cause of catarrh in children, who are particularly liable to suffer from chronic rhinitis after one of the infective fevers, especially scarlet fever or measles.

The **symptoms** are those of excessive secretion and nasal obstruction, together with the secondary results of the obstruction; thus catarrhal or suppurative otitis media is liable to result from the spread of inflammation to the Eustachian tubes, there is usually some impairment of the general health, and dyspepsia is often caused by the muco-purulent secretion swallowed Not uncommonly the inflammation is most marked in the posterior parts of the nasal passages and in the naso-pharynx, and the principal symptom is the "hawking" of thick mucus; this condition is called "rhino-pharyngeal" or "postnasal" catarrh.

Clinical appearance.—The mucous membrane of the nose may be reddened, but is most often pale, and appears to be sodden with fluid. At first the swollen turbinals are quite soft, and give to the probe the sensation of bags of liquid; but later definite thickening of the tissues occurs, and they feel firmer and no longer shrink completely after the application of cocaine and adrenalin. The thicken-

ing is most marked where the mucosa is normally most abundantly supplied with vessels and glands, over the inferior turbinal (Fig. 685), especially at its extremities, and along the lower border of the middle turbinal. Thus no sharp line of demarcation can be drawn between hypertrophic rhinitis and simple chronic catarrh, of which the former is merely a further development.

Diagnosis.—In all cases of *hypersecretion* the diagnosis of chronic catarrh should only be made after excluding other causes, especially disease of any of the accessory cavities. In these the discharge is not scattered over the nasal cavities, but is seen to exude

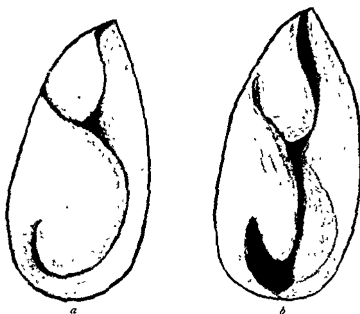


Fig. 685.—(*a*) Engorgement of inferior turbinal. (*b*) The same after the application of cocaine and adrenalin.

from one or more definite spots in the neighbourhood of the various ostia, and to reappear in the same region after being wiped away. The discharge of chronic rhinitis is bilateral, and, though often mucopurulent, is never true pus, when a definite discharge of pus is present some other cause must be sought for. Mucous polypus produces symptoms identical with those of catarrh, and must be excluded by inspection. Recurring attacks of vaso-motor rhinorrhœa are often mistaken for rhinitis, and, indeed, the distinction is frequently difficult; the symptoms come and go with greater rapidity, the discharge is watery and associated with sneezing, it is not the result of infection from another case nor does it infect others, and a bacteriological examination reveals no infection.

Treatment.—Chronic rhinitis is not a purely local affection, and the predisposing causes already mentioned must be inquired into and treated if a successful result is to be obtained. Of local treatment the most important is nasal syringing. Some care is required in the use of this remedy; the instrument should be one by which it is impossible to force fluid into the nose under any considerable pressure, or it may enter the middle ear and cause an acute otitis. The best syringe for simple cases is a small rubber ball with a blunt nozzle also of rubber, and moulded in one piece. A Higginson syringe is useful in severer nasal affections, where prolonged syringing is indicated, but it should always be provided with a fine nozzle which cannot block the nostril. The siphon-douche is dangerous, and should not be used. The lotion must be comfortably warm, about 90° F.; it is syringed gently into the nostril while the patient breathes through the mouth and inclines the head over a basin; in this way the palate is raised and the lotion passes through the naso-pharynx and out by the other nostril. If one side is much more blocked than the other, the syringe should always be applied to the obstructed side, to avoid undue pressure in the naso-pharynx The nose must not be violently blown after syringing. The mucosa is very sensitive, and the lotion must be quite unirritating; plain water produces osmosis and is harmful, but normal saline solution does very well. It is better to use a slightly alkaline lotion to dissolve the mucus, and a mild antiseptic may be added. Some modification of Dobell's solution, such as sodium bicarbonate 3 gr, sodium biborate 3 gr., carbolic acid 1 gr, glycerine 45 minims, water to 1 oz, is usually employed. Occasionally syringing causes headache, and the lotion may then be used with a coarse spray-producer. A very weak solution of potassium permanganate ($\frac{1}{8}$ gr to the ounce) may be ordered, or some other antiseptic such as sanitas; but strong germicides and astringents must never be employed.

Chronic Purulent Rhinitis

This affection occurs in unhealthy children, who are often said to have the "strumous" diathesis, especially as a sequel of one of the infective fevers. In the diagnosis it should be remembered that unilateral suppuration in children is usually due to a foreign body, and that a purulent rhinitis may be the result of congenital syphilis These cases must be patiently treated by regular syringing, for there is no doubt that, if this were done more often, there would be fewer cases of incurable atrophic rhinitis and of aural suppuration. Syringing is difficult in very young children, and a good plan is to pour some 15 or 20 drops of the warm lotion from a pipette into each nostril while the child lies on the back.

Hypertrophic Rhinitis

This is the result of long-continued chronic catarrh, and may be considered to begin when the swelling of the mucosa has resulted in structural thickening of the tissues. This hypertrophy is most *decided* over the turbinals, where the mucous membrane is normally thick, and especially over the extremities of the inferior turbinal. Large papillary masses may be found on the anterior end of the latter, and tucked under its concavity, and the posterior end often forms a rounded swelling which may be so large as almost to fill the choana; the surface of this, when not fully engorged, has a mammil-

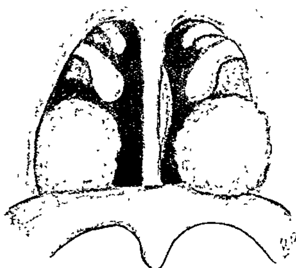


Fig. 686.—Moderate enlargement of the posterior ends of the inferior turbinals, seen by posterior rhinoscopy.

lated appearance, and is often spoken of as a "moriform" hypertrophy. (Fig. 686.) The symptoms are those described under Chronic Rhinitis (p. 251). Where the enlargement is chiefly due to venous engorgement, the offending turbinals are swollen when the patient is recumbent, though they may not appear enlarged at the moment of examination; but a slight concave groove, which may then be seen on that part of the septum where the turbinal habitually presses, will suffice to show that the case is one of intermittent obstruction (Fig. 685).

Treatment.—In the slighter cases a nasal lotion will afford relief. When the turbinal enlargement is soft and shrinks under cocaine, cauterization may be relied on to cause improvement. The result is to produce a scar binding the mucosa to the bone, but the effect is not entirely permanent The galvano-cautery is

away it should be cut off with the snare after *partial division of the* attachment with scissors; or, if preferred, the lower border may be notched with punch-forceps *to receive the loop* of the snare, the barrel of which is pushed well up *to the anterior end of the attachment* of the bone. The normal middle turbinal has often to be *removed* in the same way to obtain access to the posterior accessory sinuses.

Rhinitis Sicca

This common condition results from failure of the nasal mucosa *to saturate the inspired* air with moisture without itself becoming

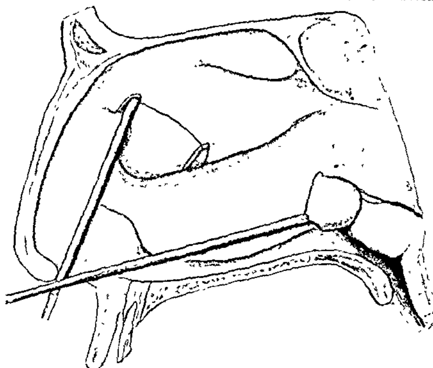


Fig. 688.—*Removal of posterior end of inferior turbinal with the snare* guided by the finger in the naso-pharynx; excision of the anterior end of the *middle turbinal with the* snare, *after making a notch* for its insertion with punch-forceps.

dry. The causes are anæmia, dyspepsia, alcoholism, or any constitutional disturbance which may interfere with free nasal circulation and secretion, and also the breathing of an unusually dry and hot air, as by *cooks and stokers*. The *trouble is most* marked where the current of air first impinges, and a dry patch is often seen on the lower and front part of the septum. The epithelium loses its ciliated character, and dry mucus and dust collect. *This is removed* by forcibly blowing or picking, and a small erosion is apt to form; the commonest source of epistaxis is from such an erosion opening

into a vein which crosses this area. In the severest cases the erosion deepens until a complete perforation of the septal cartilage is formed, and slowly enlarges by erosion beneath small crusts adherent to its margin. This, the so-called "idiopathic perforation" (Fig 689), is round and smooth and remains confined to the septal cartilage—a point of distinction from syphilitic perforation, which involves the bone.

The affection is often associated with catarrhal or dry pharyngitis and laryngitis, and the **symptoms** are those of dryness and discomfort with, perhaps, occasional epistaxis; but many patients with a large idiopathic perforation are quite unaware of any abnormality.

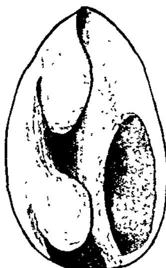


Fig. 689.—"Idiopathic" perforation of septum nasi.

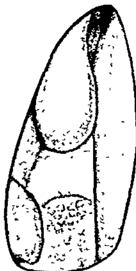


Fig. 690.—Atrophic rhinitis.
The posterior wall of the naso-pharynx and part of the anterior surface of the sphenoid are plainly visible.

The **treatment** consists in the regular use of an emollient painted into the nose or applied with a spray, such as menthol 15 gr., paraffinum liquidum 1 oz, the treatment of any constitutional condition, and the avoidance of excessively dusty or dry air.

Atrophic Rhinitis

The term "ozæna," sometimes used as a synonym for atrophic rhinitis, implies simply a stinking condition of the nose, which may also be produced by neglected sinus disease, by a foreign body, and especially by syphilitic necrosis.

Etiology.—Atrophic rhinitis, the commonest cause of ozæna, presents certain definite characters. It attacks females more often than males in the proportion of 3 to 1, and cases usually first present

themselves for treatment about the age of 15–18; but it begins before that period, and a history of nasal discharge through childhood can frequently be elicited. In nearly half the cases a peculiar physiognomy is to be observed; the face is broad, the skull brachycephalic, the bridge of the nose wide and flat, and the nostrils are broad and so directed forwards as to be unusually conspicuous. The affection is occasionally unilateral, in which case the septum is deflected and the disease is found on the wide side. The influence of heredity can often be traced, those members of a family being affected who show the peculiar facial characteristics. No specific bacillus has been found; the condition occurs at too early an age to be the final stage of hypertrophic or dry rhinitis, nor is it due to accessory-sinus disease, which can be excluded in the majority of cases. It is most probably the sequel of prolonged purulent rhinitis in childhood, which results in the replacement of the ciliated by squamous epithelium, and thus destroys the chief agent for the removal of secretion. Retention is further assisted by the undue width of the nasal fossæ, which diminishes the force of the expulsive current of air and tends to dry the secretion. So crusts of dried mucus are formed and decompose, and the continued inflammation prevents the development of the turbinals and further increases the width of the nasal fossæ.

Pathology.—The columnar ciliated cells are replaced by squamous epithelium over the inferior and middle meatus, the submucous glands are degenerated, the venous sinuses have disappeared, and the entire mucosa is thinner and more fibrous than normal.

Symptoms.—The discharge consists, not of pus, but of mucus mixed with shed epithelial cells; this collects and dries into large greenish-black crusts, which give rise to a peculiar sweetish and horribly offensive stench. The sense of smell is lost, so that the patient is not conscious of the odour. There is generally some ill-health from toxic absorption.

Objective appearances.—Although the peculiarity of physiognomy already mentioned is not constantly present, the nose is always somewhat wide; the bridge, seen in profile, is flat and straight, and differs both from the saddle-back nose of congenital syphilis and the broken contour of necrosis (see Fig. 691). The inferior turbinals are reduced to mere ridges and their [illegible] is pale and thin; but the middle turbinal is often somew[illegible] oedematous. The posterior parts of the nares and [illegible] and wall can be well seen from [illegible] (Fig. 690).

Complications.—In[illegible] from the septic nasal cavit[illegible] accessory [illegible] puration is more often [illegible] very comm[illegible] [illegible]d tissue o[illegible]

in many cases conspicuously absent, and pharyngitis with laryngitis *is common; sometimes the crusting extends to these parts, and* even down the trachea.

Prognosis.—As the ciliated epithelium can never be replaced, the affection is not completely curable, but the crusting becomes less troublesome as time goes on, and tends to cease about middle age. *The only direct risk* to life is the spread of crusting down to the larynx and trachea. It is said that the subjects of atrophic rhinitis are especially liable to phthisis, as might *a priori* be expected from

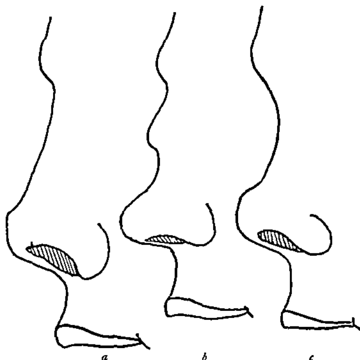


Fig. 691.—Profile of the nose typical of (*a*) atrophic rhinitis, (*b*) acquired syphilis with destruction of the septum, (*c*) congenital syphilis.

the loss of the nasal functions; and by some observers tuberculosis is held to be a factor in the causation of the affection.

Treatment.—The nose must be kept free by regular syringing with a *mild antiseptic alkaline lotion, of which a large quantity must* be used with a Higginson syringe and a long, fine nozzle which cannot block the nares. The surgeon should see that this is properly done at the beginning, and himself remove adherent crusts. After syringing, the nares are thoroughly sprayed with a stimulating oil, such as oleum eucalypti 15 minims, paraffinum liquidum to 1 oz, or a 25-per-cent. solution of glucose in glycerine may be applied with a

brush or on gauze packing. The crusting can be prevented by the exclusion of air, and in bad cases it is advisable to do this at first by lightly packing the anterior part of the nose with gauze; this is changed twice a day and the nose syringed. After a few weeks the packing can be gradually omitted, but the syringing and spraying are continued indefinitely. The odour is immediately abolished with the crusting by packing the nose, and the discharge is then seen to be mucoid. If, after a few days' treatment, the surgeon removes the packing himself he can at once see if any pus is present, and so diagnose or exclude sinus disease. Tonics, cod-liver oil, and change of air, especially to the seaside, are beneficial.

Paraffin wax may be injected under the mucosa of the rudimentary inferior turbinals in order to remedy the undue patency of the nasal passages, and so to diminish crusting and help the patient to clear the nose by blowing. The paraffin, however, will not always remain in position beneath the extremely atrophied mucous membrane.

Rhinitis Caseosa

This is a rare affection, always unilateral, and characterized by the collection of a mass of very foul cheesy material in the middle meatus or olfactory slit. It is due to putrefactive changes in pus from an accessory sinus, necrosis, or foreign body. It is treated by thorough removal of the mass, cleansing of the parts, and drainage of any sinus involved.

Membranous or Fibrinous Rhinitis

The Klebs-Löffler bacillus occurs in the nose in two very different clinical conditions. It would appear that the nasal mucosa is inimical to this organism, which can therefore only exist in the nose in modified form, unless its virulence is extreme. Thus, true nasal diphtheria may result from the spread of the disease from the fauces, and is a sign of high virulence and a very fatal complication. The nasal symptoms are obstruction and profuse acrid or sanious discharge which excoriates the skin of the nostril and lip. On the other hand, there is a form of primary membranous rhinitis due to the diphtheria bacillus, which is purely local in character and not associated with constitutional disturbance or followed by paralysis. This affection, often called fibrinous rhinitis, occurs in children, and is associated with the formation of a large quantity of thick false membrane. There is a third form of membranous rhinitis, which is much rarer than the other two, and is not caused by the Klebs-Löffler bacillus, but by staphylococci or streptococci, and is analogous to the non-diphtheritic membranous inflammations of the fauces.

The **treatment** of fibrinous rhinitis consists in cleansing the

nares with the usual warm alkaline nasal lotion and a bland spray of liquid paraffin. It is useless to remove the membrane forcibly, and strong antiseptics only do harm. Antitoxin is also useless. True nasal diphtheria is, of course, to be treated on the usual lines.

EPISTAXIS

Etiology.—The causes of epistaxis may be classified as follows :—

1. *Injuries:* surgical operations, blows on the nose, or fracture of the base of the skull.

2. *Local conditions:* the small septal erosion of rhinitis sicca, which is the commonest cause of epistaxis; ulceration produced by foreign bodies, the granulomata, or malignant disease; "bleeding polypus" of the septum; and multiple telangiectases, a curious hereditary affection characterized by numerous minute capillary dilatations on the face and on the mucous membranes of the nose, mouth, and throat.

3. *Constitutional affections* which raise the blood-pressure: cirrhosis of the liver, chronic nephritis, arterio-sclerosis, cardiac disease, the early stage of fevers such as enteric, congestion at the menstrual period or "vicarious menstruation," and mechanical congestion from thoracic tumours or from the effort of coughing as in pertussis. The purely local hyperæmia of acute rhinitis is not accompanied by hæmorrhage.

4. *Diseases of the blood* affecting its coagulability: pernicious anæmia, leukæmia, purpura, scurvy, and hæmophilia.

The **source of the bleeding** is—(1) From a small vein crossing the lower and front part of the septum; this is by far the commonest site of epistaxis, especially in rhinitis sicca and the cases due to a high blood-pressure. (2) From the region at or above the middle turbinal; it is then apt to be very severe—a fact explained by the connexion of the anterior ethmoidal veins with the intracranial circulation. (3) In cases of ulceration and new growths the bleeding comes from the site of the lesion, which may be anywhere in the nose; hæmorrhage after injury usually proceeds from the septum, but when the base of the skull is broken the hæmorrhage passes through the roof of the nose, and may be very profuse and persistent. (4) In the blood diseases there is often a general oozing. The blood from the nose may pass backwards and be swallowed and vomited, or may be coughed up from the larynx.

Treatment.—When the bleeding is dependent on high blood-pressure or congestion, it is beneficial within reason, but must, of course, be checked if persistent; venesection is a preferable alternative. Hæmorrhage from a septal erosion, uncomplicated by high tension, can generally be stopped by compressing the nostrils, especially

if a pledget of wool, moistened with adrenalin, be introduced into the affected side. The use of an emollient oil will serve to prevent recurrence. If the *bleeding be persistent or recurrent*, as usually happens when the blood-pressure is high, the bleeding-point must be found, started, if necessary, with a probe, controlled by application of cocaine and adrenalin on a plug of wool, and sealed by the galvano-cautery at a dull-red heat. It is not uncommon for the hæmorrhage to recur from another spot or from the other naris, when the process must be repeated. Saline purgatives should be freely *prescribed, and calcium lactate* may be given in 10-gr. doses three times a day. As in all forms of hæmorrhage, a rapid excited action of the heart is generally present, associated with restlessness and fright, and an injection of morphia is of great value. Minor measures are the application of iced water to the face, hot water to the feet, and syringing the nose with saline solution as hot as can be borne. Powerful astringents must never be applied. Plugging the nose is *rarely needed, except for the severe bleeding of the hæmorrhagic diseases* If it is necessary it should be carried out with ribbon-gauze packed in evenly on forceps under inspection. These plugs quickly become septic, and may cause disease of the sinuses or ears, but they may be retained for forty-eight hours or longer if frequently moistened with 10-volume peroxide of hydrogen. The old method of plugging the posterior nares is quite unnecessary, and may do *harm by forcing the blood to accumulate in the accessory cavities.*

SYPHILIS

Congenital Syphilis

The *early form* appears within three months after birth, as a chronic catarrh with obstruction and discharge, and frequently some crusting and fetor; necrosis is extremely rare. The symptoms of "*snuffles*" are by no means always due to syphilis, but often to simple catarrhal or purulent rhinitis, and it is seldom that mucous plaques or definite erythema can be observed in the nose to clinch the diagnosis, which must be established by concomitant lesions. The *late form*, which shows itself after the age of 5, resembles clinically the tertiary stage of the *acquired disease.*

Congenital syphilis is apt to produce extreme flattening of the bridge of the nose (Fig. 691, c), which is the result of non-development rather than of necrosis. The syphilitic rhinitis of infancy destroys the ciliated epithelium, and may thus produce atrophic rhinitis after all active disease has ceased.

Acquired Syphilis

The *primary* sore occasionally *occurs on the ala of the nose,* and is accompanied by a bubo of the submaxillary and preauricular

glands and, like other extragenital chancres, by much swelling and induration.

Secondary syphilis causes few symptoms and is seldom noticed in the nose. There may be catarrh, and rarely mucous patches are to be seen.

Tertiary nasal syphilis usually takes the form of diffuse gummatous infiltration and ulceration, which often proceeds to necrosis of the turbinals and the cartilaginous and bony septum There is much purulent discharge, often blood-stained, which dries into greenish-black crusts; the odour, especially if necrosis has taken place, is extraordinarily fetid. A localized gumma may occur, usually on the septum, where it forms a firm round swelling projecting into both nares. The ulceration sometimes affects the soft parts, causing perforation or destruction of the ala or columella; the latter produces a peculiar depression of the tip of the nose. The most characteristic deformity is a sudden depression of the bridge immediately below the nasal bones (Fig. 691, *b*); but the same deformity, as already pointed out, may result from suppuration of a septal hæmatoma.

The **diagnosis** presents little difficulty; there is no necrosis or ulceration in atrophic rhinitis. The septal perforations of rhinitis sicca or of lupus are always confined to the cartilage. A gumma of the septum closely resembles a hæmatoma, but has arisen more slowly and without a history of injury.

Treatment.—Mercury should be given as well as the iodides in tertiary cases, and the latter in large doses If a perforation of palate or ala threatens, rapid treatment by salvarsan, or by intramuscular injection of mercury, is indicated. In addition, cleansing douches are required, together with the removal of any necrosed bone.

TUBERCULOSIS AND LUPUS

Etiology.—These diseases will be considered together, for the lesions produced in the nose by tuberculosis and by lupus are indistinguishable. The theory propounded by Escat, which has been widely accepted, appears to be in accordance with the facts, and may be enunciated as follows. The tubercle bacillus finds in the nasal mucosa a medium unsuitable for its development, and if it obtain a lodgment its virulence is diminished and it can only produce the modified and local lesions known as lupus. Again, the cause of lupus is this modification of the tubercle bacillus by its sojourn in the nose, and it therefore follows that the primary lesion of lupus is always in the nasal cavity, whence it spreads to the face, inoculates the backs of the hands and other regions of the body, and extends to other parts of the upper air-passages. When lupus attacks the upper air-passages

it shows, in contradistinction to true tuberculosis, evidence of travelling from above downwards, affecting the upper surface and border of the soft palate, and, in the larynx, the edge of the epiglottis before its interior. With the exception, therefore, of a few cases, where the nose is involved in the last stage of phthisis, nasal tuberculous lesions are primary, chronic, and local, and should be considered as lupus. The disease is most frequent in young women. The infection is usually conveyed by the finger-nail, and the initial lesion is nearly always on the lower and front part of the septum, but the anterior ends of the inferior and middle turbinal bodies are often involved. The typical brownish-red nodules are seen with or without ulceration, the latter rounded in shape with slightly raised margin and tending to cicatrize in places. The lesions are often partly covered by small dry crusts. Perforation of the septal cartilage is frequent, but the bones are not attacked. The vestibule and alæ often become involved, and the nostrils may be much narrowed and deformed by scarring. Enlargement of the submaxillary and especially of the preauricular glands is common. The nasal **symptoms** are merely discomfort, dryness, slight discharge, and obstruction. The **diagnosis** is simple when the skin, larynx, or fauces are affected; the disease is distinguished from syphilis by its slow course, absence of bone destruction, and scanty discharge, and by the characteristic nodules which stand out more clearly after the surrounding membrane has been made pale by adrenalin.

It will be understood that **treatment** of the intranasal lesions must never be neglected in cases of cutaneous lupus, or reinfection will continually occur. A general anæsthetic is advisable if the affection is at all extensive. After the disease has been defined by using adrenalin, it is very thoroughly removed with a sharp spoon and lactic acid rubbed in; affected parts of the turbinals should be amputated. Recurrences must be watched for and promptly treated; small lesions may be destroyed with the cautery. The cases are readily improved, but complete cure requires great care and patience. Arsenic in full doses, with good food and fresh air, is very helpful. Tuberculin does good occasionally, but the result is more often disappointing. The dose should never be large enough to produce marked local reaction, and should be increased very slowly; $\frac{1}{25000}$ milligramme (T.R.) is sufficient for the first injection, and the dosage and spacing must be guided by the reaction. Pfannenstill's nascent iodine method may be employed. Sodium iodide is given by the mouth in 7-gr. doses six times a day, while the nose is lightly packed with gauze kept moist with peroxide of hydrogen in 10-volume strength to which 5 per cent. of acetic acid has been added; when a marked reaction has been obtained, this solu-

tion is diluted to half its strength, the iodide being continued as before. If improvement is occurring the treatment should be continued for several months.

RARE NASAL INFECTIONS

Leprosy [1]

The nodular form of leprosy commonly attacks the external parts of the nose, giving it a peculiar broadened or trilobed appearance, and spreads thence into the nares. At first there is a nodular deposit, which later ulcerates and destroys the cartilaginous septum and often the alæ also. The disease tends to spread backwards to the fauces and larynx. The early symptoms are obstruction and anosmia, but later, when ulceration has occurred, there is profuse watery discharge with a very foul odour. The local treatment consists in cleansing with a warm alkaline lotion, and spraying with a mild antiseptic such as a 1-per-cent. solution of resorcin.

Scleroma

This name is preferable to rhinoscleroma, as it also attacks the pharynx and larynx. It is indigenous in South-Eastern Europe, Egypt, India, and South America, and is only seen in this country in persons from infected areas. The affection is due to a micro-organism, and begins in the vestibule with the deposit of small, very hard nodules covered by normal skin. It extends very slowly into the nares, the mucous membrane appearing smooth, shiny, and very hard. The progress is extremely slow, and is accompanied b[illegible] [illegible] ulceration, discharge, or pain, a[illegible] obstruction; but when the l[illegible] œa result. The mechanical obstruction may be attacked surgically, and the wounds heal well. Radium and Rontgen rays have given very promising results; arsenic is said to be useful.

Glanders [2]

The *acute* form is the commoner in man, but here the lesions are less localized to the nose. The *chronic* form is of more importance to the rhinologist, as it may be confined to the nose and cause great difficulty in diagnosis. The mucous membrane is swollen and painful and covered with viscid discharge and scabs; ulceration supervenes, and the affection often spreads to the pharynx and larynx. These cases occasionally recover, but more often the disease becomes generalized and kills in about six months. The diagnosis can only be made by detection of the *Bacillus mallei*, the inoculation of a male guinea-pig, or the injection of mallein on the same lines as tuberculin. No form of local treatment has any curative value, but antiseptic applications should be used to cleanse the nasal passages.

MUCOUS POLYPUS

Etiology.—Nasal polypi sometimes occur in childhood, but are very rare before puberty, and are somewhat commoner in men than in women. They always grow from the ethmoidal region, and are never found attached to the inferior turbinal, septum, or nasal

[1] *See also* Vol. I, p. 893   [2] *See also* Vol. I., p. 904.

the probe: this appearance is so characteristic that there is no excuse for diagnosing an enlarged turbinal as a polypus. If they protrude near the nostril they are often pink and more opaque. They usually have a narrow pedicle, but also occur as a flattened fringe-like appendage along the lower border of the middle turbinal. They vary in size from minute bodies to enormous masses filling the cavities of the nose and naso-pharynx.

Treatment.—The best method of removal in ordinary cases is with the cold snare, which can be rendered quite painless with care-

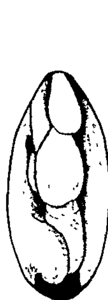


Fig. 692.—Nasal polypi.

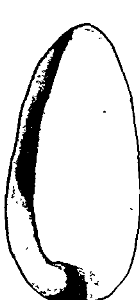


Fig. 693.—Septal deviation.

The main convexity is to the right, and the anterior end of the septal cartilage is dislocated into the left nostril, there is a large vomerine crest on the left side

ful local anæsthesia and skilful manipulation. The snare should have a cross-bar at the end of the barrel to prevent the wire from being completely withdrawn, as this cuts off the polypus and leaves it in the nose. The loop must be passed as near as possible to the attachment of the growth, and should not be tightened so much as to cut it through, but only to grasp it firmly and pull it away; by this plan the entire polypus is removed, often with a fragment of carious bone in its base. To prevent recurrence any polypoid mucous membrane near the origin of the growths should be cut away with punch-forceps and, if necessary, part of the middle turbinal removed; I have seen no good result from application of the cautery or of caustics to this region. If pus be present, disease of the ethmoid cells and other

sinuses must be sought for and treated: In the worst cases the polypi are so numerous and recurrence is so rapid that no progress can be made with the snare. Then a general anæsthetic must be given, the polypi scraped away, and all the softened bone removed with Luc's forceps or a ring-knife. The greater part of the ethmoidal labyrinth has often to be curetted away, and, if necessary, the maxillary and sphenoidal sinuses can be opened at the same time. The bleeding is very free, and this must be considered a major operation, demanding considerable experience in intranasal surgery and anatomy. Recurrence must still be watched for, but is usually localized, and removal can be effected with the snare.

INNOCENT NEOPLASMS

True neoplasms are very rare in the nares. **Papillomas** occur on the skin lining the vestibule, and differ in no respect from cutaneous warts elsewhere.

Bleeding polypus of the septum. — These interesting tumours vary from the size of a pin's head to that of a filbert, are red or purple in colour, smooth or finely lobulated, sessile or slightly pedunculated, and bleed very readily. They are composed of young connective-tissue cells or of firmer fibrous tissue, usually highly vascular, with dilated capillaries or venous sinuses, and covered with squamous epithelium. Their characteristics differ according to the relative development of their component parts, so that specimens become variously classified as papilloma, fibroma, angioma, or granuloma. They grow on the front part of the septum, and some are probably the result of irritation or inoculation with the finger-nail. Epistaxis is the prominent symptom, and may be very profuse. The proper treatment is thorough excision which includes a portion of the underlying septal cartilage.

Fibromas similar to the naso-pharyngeal fibromas occur, though very rarely, as smooth, pink, flask-shaped growths attached to the bony septum. They also bleed readily and spontaneously, and call for great caution in removal.

Osteomas and **chondromas** are extremely uncommon, apart from the ordinary spurs and thickenings of the septum. But true tumours of this nature are occasionally found attached to the septum near the floor of the nose, and cause obstruction and external deformity.

Cysts.—Mucous polypi are sometimes definitely cystic as the result of dilatation of their mucous glands.

The so-called "ethmoidal cyst" is merely an enlarged ethmoidal cell, which expands the anterior end of the middle turbinal, presses on the septum, and causes obstruction and headaches.

True cysts are occasionally seen on the front part of the floor of the nose, and appear to be connected with the roots of the incisor teeth. Mucoceles, or cystic dilatations of the accessory sinuses, will be referred to later.

MALIGNANT NEOPLASMS

Carcinoma, sarcoma, and endothelioma all occur, but somewhat rarely, in the nasal cavities. Though they sometimes appear on the septum as a dark-coloured, smooth, or warty growth which ulcerates early, the most common site of origin is the antro-nasal wall and ethmoidal region. These tumours grow quickly and often expand the bones of the face, producing a characteristic frog-like deformity. They tend to invade and expand the antrum and the other accessory sinuses; the facial, palatine, and orbital walls of the antrum may each and all be bulged outwards, and egg-shell crackling is sometimes found. Bulging of the orbital plate of the ethmoid into the orbit is also common. When the growth fungates in the nose, mucous polypi often develop from the neighbouring mucosa, and may be mistaken for the primary disease, but sanious discharge and spontaneous hæmorrhage generally make the diagnosis clear. Many of the tumours which expand the antrum do not really invade its walls, but merely grow into it from the nose, and can be removed by operative procedures which stop short of complete excision of the upper jaws. Access to the deep parts of the nose for removal of these growths is best obtained by Moure's operation of lateral rhinotomy, in which an incision is made along the junction of the nose and cheek, combined, if necessary, with a second along the lower orbital margin, and part of the nasal bone and nasal process of the superior maxilla is removed; or by Rouge's method of making an incision in the gingivo-labial fold from the molar teeth of one side to the other, and raising up the soft parts of the face after dividing the septum along the floor of the nose. For further details the reader is referred to works on operative surgery.

DEVIATIONS OF THE SEPTUM

Etiology.—The septum nasi is very seldom perfectly straight and smooth in adults, but is rarely found deflected in children under the age of 7, except after injury. A large number of cases are due to traumatism, often to some slight forgotten injury; others appear to be due to developmental defect, especially to disproportionate growth of the septum and of the rest of the facial skeleton. Nasal obstruction by adenoids, associated with a highly-arched palate, is probably an important factor in their causation. Deflections have been ascribed, on insufficient grounds, to the forcible use of the hand-

kerchief. A deviation, once produced, *undoubtedly tends to increase*, perhaps because the narrow naris is more subject to negative pressure on inspiration.

The **symptoms** are chiefly those of nasal obstruction. When one side is much blocked and the other unduly patent, one often sees marked rhinitis sicca and occasionally atrophic rhinitis of the wide nostril; *postnasal catarrh and catarrhal otitis media* are common. The deviation may, by pressure on the outer wall of the nose, produce discomfort and even severe headache, and may set up various neuroses.

Objective appearances.—Deflections are most common and most marked in the anterior part of the nose. The usual forms are those already described under Fractures (p. 244), but any shape may be found. *Bony and cartilaginous ridges, the so-called "spurs,"* are common along the upper border of the vomer; they usually end abruptly behind, and seldom extend to the posterior border of the bone; indeed, it is rare to find a deflection which is visible by posterior rhinoscopy. These crests or spurs are nearly always part of a deviation, and a corresponding depression can be seen on the opposite side. *In cases of long standing the turbinals on the concave side* have usually undergone compensatory hypertrophy. The anterior end of the triangular cartilage is sometimes dislocated from its bed in the columella, and projects into the nostril on the side of the concavity of the deflection; the inner limb of the lower lateral cartilage is occasionally dislocated, and forms a small prominence on the inner side *of the nostril, farther forwards and more movable than that caused* by the end of the triangular cartilage. (Fig. 693.)

Treatment.—Only those septal deviations require treatment which are definitely productive of symptoms, and these form but a small proportion of the entire number of cases. The operation of submucous resection has now superseded all other methods; by this operation the septum is not only placed in the middle line, but is also straightened and reduced in thickness, without the sacrifice of any of the valuable mucous membrane.

Submucous resection.—The operation may be performed under local or general anæsthesia. Very complete local anæsthesia is obtained by packing wool, moistened with a solution of cocaine and adrenalin, against the septum, and then injecting beneath the muco-periosteum on both sides a solution composed of 2-per-cent. novocain and 1 : 10,000 to 1 : 15,000 adrenalin, of which a drachm may be used with safety. When general anæsthesia is employed, adrenalin must also be applied beforehand, and a submucous injection of the diluted adrenalin may be given, but always before the general anæsthesia is commenced; it is dangerous in the highest degree to inject adrenalin into a patient under chloroform.

An incision nearly vertical in direction is made on the convex side in front of the deflected portion, and the muco-periosteum raised from the cartilage and bone as far as the deflection extends. An incision is now made through the cartilage, great care being taken not to damage the mucosa of the opposite side, which is then raised in the same manner. The operation is thus carried out entirely through one naris (Fig. 694), but the movements of the elevator on the far side may well be watched through the opposite nostril. A long nasal speculum is next introduced into the incision so as to hold away the two layers of muco-periosteum and to contain the cartilaginous and bony septum between its blades. The deviated septal cartilage is then cut away with angular knives or with Ballenger's swivel-knife, care being taken to leave a strip of the cartilage along its upper border to obviate any possibility of sinking of the bridge. If the perpendicular plate is deflected, this is removed as far as necessary with strong punch-forceps. The lower part of the bony septum remains to be dealt with: this is very dense, and is best removed by driving a fine chisel along the floor, seizing the bone in strong forceps, and breaking its posterior attachment. When all the deflection has been removed, a strip of ribbon gauze is packed lightly and evenly into the originally convex naris, to prevent any accumulation of blood or serum between the two leaves of mucous membrane, and is removed after twenty-four hours, when no further after-treatment is required. Stitches are unnecessary. The compensatory enlargement of the inferior turbinal of the concave side may call for treatment by cautery or partial removal. If the anterior end of the triangular cartilage is dislocated, the incision is made over its prominence; the perichondrium will here be found very adherent.



Fig. 694.—Submucous resection.

The cartilage has been divided and the muco-perichondrium separated on both sides through a single incision in the left naris.

NASAL OBSTRUCTION

Effects.—The most obvious result of nasal obstruction is mouth-breathing. Dryness of the mouth and throat, especially on waking in the morning, is a constant symptom, but the resulting discomfort varies greatly in different patients. Oral sepsis is largely promoted by mouth-breathing. Pharyngitis and laryngitis are frequently the result of nasal obstruction; in addition to the effect of the cold, dry, and unfiltered air, the deficient nasal resonance throws

an extra strain on the larynx in producing the voice In chronic bronchitis nasal obstruction is not uncommonly the determining *factor*, and there is evidence to show that it increases the liability to pulmonary tuberculosis. The *naso-pharynx* and posterior parts of the nose behind an obstruction often show catarrhal swelling, which tends to disappear after a free air-way has been restored; this catarrh readily spreads to the Eustachian tube and middle ear. The long,



Fig. 695.—*Adenoid facies.*

This and the following figure illustrate the slit-shaped nostrils, the high palate, the narrow dental arch, *the defective teeth*, and the non-apposition of the anterior teeth when the jaws are closed

narrow chest, indrawn ribs, and pigeon breast frequently seen in cases of adenoids appear to be directly due to inspiratory obstruction. Deficient oxygenation of the blood causes another group of symptoms; during sleep in mouth-breathers, when the tongue drops back, a *considerable* degree of asphyxiation takes place, and such people wake unrefreshed, with a dull headache and general lassitude. Frontal headache *is also caused* by *pressure* of the swollen parts

within the nose. Many patients with nasal obstruction suffer from a peculiar inability to concentrate the attention, to which the term "aprosexia" has been applied. Children often show marked failure of growth and health.

Persistent nasal obstruction during the period of growth, such as is caused by the common adenoid hypertrophy, mechanically produces permanent deformities of the bones of the jaws and face,



Fig. 696.—Adenoid facies.
(*See* inscription to Fig 695)

which tend to narrow the nares, to prevent the mouth from firmly closing, and thus to perpetuate the condition of mouth-breathing. (Figs. 695, 696.) At the second dentition the antrum expands rapidly, the tuberosity of the upper jaw is developed, and the permanent molars are carried down into their final position. In infancy the angle of the lower jaw is very obtuse, but adaptation to the altered shape of the maxilla causes it to approach a right angle. Now, when

the mouth is kept shut the tongue exerts a constant outward pressure on the sides of the alveolar arch, and at the same time a certain negative pressure is produced between the roof of the palate and the dorsum of the tongue, which helps to sustain the weight of the lower jaw. Thus the dental arch is widened and rounded in front, and the palate is rendered wide and flat; this necessarily makes the nasal fossæ wider and deeper. When, however, the mouth is habitually held open these forces cease to act, and the open jaw is supported by the cheeks, which thus press inwards on the molar teeth. The alæ nasi are pulled downwards with the cheeks, and the lower jaw, seldom in contact with the upper, retains its obtuse angle. Thus is produced the facial deformity so common in those who have suffered from nasal obstruction during growth. The nares are narrow and the slit-like nostrils fall in like valves with each inspiration, because the dilator muscles are undeveloped; this "alar collapse" is an important cause of obstruction in such cases. The roof of the palate is high and pointed like a Gothic arch, and the dental arch is narrow and V-shaped; the incisors, prominent and crowded, look outwards rather than forwards, and, owing to the obtuse angle of the mandible, in the worst cases the front teeth of the upper and lower jaws do not meet, so that the mouth is permanently open and the lips can only come together with difficulty, the chin is receding, and the lower incisors lie behind the upper. This deformity does not arise to the same extent in every case of nasal obstruction, and undue softness of the bones, such as occurs in rickets, is doubtless an important additional factor.

Treatment.—The treatment of adenoid hypertrophy, the commonest cause of obstruction, is discussed elsewhere (*see* p. 296). In treating cases of nasal obstruction it must never be forgotten that the mucous membrane, especially over the inferior turbinals, subserves an important physiological function and must not be recklessly sacrificed. It is always better to resect submucously a septal deviation than to make room by excising turbinal tissue. The inferior turbinal must never be entirely removed, or a condition of atrophic rhinitis is likely to be set up. If part of the mucosa is destroyed in the course of a submucous resection, it is replaced by scar tissue covered with squamous epithelium where dryness and crusting may occur. A complete perforation anteriorly is apt to cause discomfort from crusting along its margin, and occasionally a whistling sound on respiration; but a perforation far back in the nose usually produces no symptoms. The maldevelopment described above, which causes a narrow "cramped" condition of the nares, is very difficult to treat satisfactorily, for it is obvious that in adults the malformation of the jaws cannot be corrected. The

septum is rarely straight in these cases, and the best results are usually obtained by a submucous resection which reduces the thickness of the septum to a minimum. The alar collapse is diminished by relieving the obstruction behind, and especially by treating any septal deformity at the level of the alar groove; props to support the alæ may be worn at night. Breathing exercises are of great value in restoring the action of the dilator muscles, more especially in children after the adenoid operation, and much good can be done by the dental surgeon in expanding the narrow dental arch.

Operations for nasal obstruction cannot be performed under perfect aseptic conditions, but the nose does not normally contain virulent micro-organisms, and every precaution must be taken to avoid introducing them. Wounds within the nose usually heal well and quickly, but septic complications are by no means unknown. The most frequent of these manifests itself as an inflammation of the fauces or as a definite tonsillitis. Acute otitis media sometimes occurs, and may be of great severity. Experience shows that the liability to this complication is increased by nasal douches after operations on the nose and throat.

NEUROSES

Anosmia is most often caused by any local obstruction which prevents access of air to the olfactory region in the superior meatus; as the expiratory current reaches this area more readily than the inspiratory, the perception of savours is not completely lost in the slighter of such cases. The olfactory nerve-endings may be damaged by inflammation, as in atrophic [illegible]

Hyperosmia and parosmia, or subjective perception of odours, are functional disturbances, often associated with insanity.

Hay-fever occurs in people of a neurotic tendency, and generally of [illegible]

of Dunbar have shown that it is due not to mere mechanical irritation, but [illegible]

[illegible] with advancing age.

Paroxysmal rhinorrhœa, also called *vaso-motor* and *spasmodic rhinorrhœa*, is a very similar affection which, not being due to a seasonal irritant, occurs at any and all times of year. Predisposing causes are sexual excitement and mental shock and depression. The fits of sneezing and dis-

charge are usually worse in the morning and last for several hours, sometimes causing great exhaustion; the conjunctival symptoms are less marked than in hay-fever. In some patients an attack is excited by contact with horses, cats, or dogs. Often there is a history of asthma, either personal or among relatives; and some suffer from urticaria, with which the affection is closely allied. Recent researches point to the probability *that this affection is in* many cases an example of anaphylaxis, and that individual sufferers show susceptibility to a great variety of proteins absorbed either by inhalation, as *the emanations of plants and animals, or by ingestion in* various articles of diet, not only in such foods as shell-fish and mackerel, but in commonly-eaten things such as eggs or wheat-flour. Thus hay-fever, paroxysmal rhinorrhœa, asthma, angioneurotic œdema, and urticaria are all manifestations of a similar condition.

Treatment [illegible]

Nerve tonics, strychnine, arsenic, and valerian, are indicated, with general attention to the health, and liquor atropinæ in ½-minim doses combined with [illegible] for hay-fever patients [illegible] ny such patients [illegible] a small island [illegible] *en extract*, sold [illegible] sh the susceptibility to hay-fever toxins; the dose should be controlled by the conjunctival or cutaneous *reaction, and the injections should be given every ten days for* at least three or four months before the hay-fever season begins. In most cases considerable benefit results, but the injections must be repeated for, at any rate, several years. *In* non-seasonal cases *the* patient's *reaction to* [illegible] to which he is sus- [illegible]

a definite source of irritation is present, such as a septal spur impinging [illegible] the turbinal, and in such cases marked relief or complete cure sometimes [illegible] always [illegible]

followed by distinct improvement [illegible] and requires repetition at intervals; but such a treatment at the beginning of the season will often enable a hay-fever patient to go through the summer with comfort, and generally gives great relief in non-seasonal rhinorrhœa.

Asthma.—In spite of the many uncertainties connected with the nature and causation of these neuroses, it may be affirmed that true spasmodic asthma can be produced, in patients with hypersensitive nervous systems, by afferent impulses passing from the nasal mucosa. Asthma is often associated, in the same patient or in other members of his family, with hay-fever or paroxysmal rhinorrhœa.

We are here only concerned with the *nasal treatment* of this affection. Patients have undoubtedly lost their asthma after operations for the removal of septal deflections, turbinal hypertrophy, sinus suppuration, and *polypi*. The most successful results are obtained when there is a marked cause of irritation, as when a sharp spur presses on the turbinal body. The effect of removal of polypi is very uncertain; the

majority of cases are improved, but a few are actually made worse, and I have seen two patients who had asthma temporarily for the first time after the removal of these growths. In a large number of cases the "cure" achieved by these operations is only temporary, the asthma returning after a few months; but it may further be remarked that, if there is pronounced nasal obstruction, the symptoms of asthma are rendered much more tolerable by its removal. In most cases, however, the nose is well within the limits of the normal; in some of these much relief follows the application of the cautery to various parts of the nasal mucosa, especially over the septum opposite the anterior end of the middle turbinal. The result is rarely permanent, and it is extremely difficult to judge the effect of treatment in this disease; but it is at least a simple remedy, harmless in skilled hands, and, judiciously repeated, has done much to help a number of cases. The application of cocaine to the nose not uncommonly cuts short an attack, but in such patients the cocaine habit is very easily formed, and the drug should never be prescribed for the patient's own use in this affection. Adrenalin used as a spray is not open to the same objection, and sometimes gives great though temporary relief.

Headaches of nasal origin are sometimes due to the pressure of a nasal spur, or, more often, to an enlarged or inflamed middle turbinal which presses tightly on the septum or, by obstructing the infundibulum, perhaps produces a partial vacuum in the frontal sinus or adjacent ethmoidal cells; [illegible]

[illegible] haracter, is occasion- [illegible] a septal spur.

SUPPURATION WITHIN THE ACCESSORY NASAL SINUSES

Etiology.—In the large majority of cases the inflammation reaches the accessory sinuses by extension from the nasal cavity; the primary infection may be from a simple catarrhal rhinitis, or, more commonly, from one of the acute infectious diseases. Influenza is especially liable to produce disease of the sinuses, which may also be caused by erysipelas, scarlet fever, measles, enteric, pneumonia, or variola. The discharge from one infected sinus readily enters and infects another, so that disease of several cavities often coexists. The frontal sinus is particularly liable to infect the antrum in this way, and the sphenoidal sinus and posterior ethmoidal cells are commonly affected together. Antral empyema is sometimes caused by infection from carious teeth, especially the second bicuspid and first two molars, whose sockets lie close to the antral floor, but most cases of antral empyema are the result of infection from the nose and not from the teeth. Traumatism may be followed by sinus suppuration; the antrum and frontal sinus are naturally most exposed to injury.

The micro-organisms commonly found in these affections are the pyogenetic staphylococci and streptococci, the pneumococcus, Friedländer's bacillus, the influenza and diphtheria bacilli. The normally thin mucosa is enormously thickened, and definite polypi are sometimes present; in old-standing cases the epithelium is largely destroyed.

Clinical features.—If the ostium of a suppurating sinus be occluded the pus is secreted under pressure and the local symptoms are severe, whereas if the secretion can escape freely there may be no symptom except discharge. The former class of case has been called "closed" and the latter "open" empyema. Absolute occlusion of the ostium is very uncommon, and the difference between the two classes is only relative; many cases are alternating, the severe symptoms being relieved by periodical discharge of pus. When the secretion is very profuse there will be pressure within the cavity even if the ostium is not much obstructed, and the cause of occlusion is usually inflammatory swelling, so that the closed and open groups correspond in general to acute and chronic suppuration. The open cases, having few local symptoms, have also been termed "latent," but as they present definite nasal suppuration they are not really latent to modern rhinological methods. A few cases with scanty secretion, which may only be detected after several examinations, are really latent, and may be for long the undiscovered cause of post-nasal catarrh, pharyngitis, etc.

The symptoms, then, are those of localized suppuration, viz. swelling, pain, tenderness, and discharge, together with the secondary effects of that discharge on other parts.

Swelling is rare; it is due in some instances to bulging of the bony walls, but far more often to extension of the inflammation causing periostitis outside the cavity. Bulging of the walls of the antrum is never produced by suppurative disease, but is always a sign of a tumour or cyst within the cavity, though occasionally some slight inflammatory swelling of the cheek is present. In frontal sinusitis the thin floor of the cavity may, though very rarely, be expanded, producing a swelling at the junction of the inner and upper walls of the orbit and displacing the eyeball downwards and outwards; external periostitis is not uncommon in this situation, and an abscess may form and, after opening, leave a fistula here or on the forehead. Ethmoidal disease sometimes makes its way through the orbital plate and causes a swelling farther back on the inner wall of the orbit with outward displacement of the eye.

Pain is often severe in acute or closed-sinus disease, but in chronic cases also there may be considerable neuralgic pain. Paroxysms of pain, relieved by a sudden gush of pus from the nose, are highly

characteristic of intermittent occlusion of the ostium. The pain may be of a local inflammatory nature, or may be referred and of a neuralgic type. In antral disease the pain is over the cheek, or may be referred to the teeth or to the supraorbital nerve. This supraorbital neuralgia is a very common symptom of antral empyema, and, combined with nasal discharge, may lead the incautious to diagnose frontal sinusitis. The pain of frontal sinusitis is over the cavity or along the supraorbital nerve; that of ethmoidal suppuration is felt over the nose, behind the eye, and outwards to the temple; sphenoidal disease causes pain or pressure in the centre of the head, behind the eye, over the vertex, or in the occipital region. Referred neuralgic pain is very variable in all these cases, and its situation is of little help in localizing the disease. Tenderness gives rather more assistance, for it is often marked in frontal sinusitis on percussion over the cavity, and especially on pressing upwards and inwards against its floor; it should be remembered that the supraorbital nerve is always tender on pressure, and especially so in cases of neuralgia.

Discharge from the nose is the most important symptom, for, with the exception of a very few cases of closed empyema, it is always present, though in some chronic cases it may be very scanty. The discharge from the nose of true pus, as distinguished from a mucopurulent secretion, is always due to disease of an accessory sinus if the presence of foreign body, necrosis, and syphilitic ulceration be excluded.

The effects of the discharge include subjective fetor or cacosmia, pharyngitis, laryngitis, otitis, dyspepsia, and general ill-health; a serious degree of anæmia and cachexia not uncommonly ensues.

Complications of a very serious nature may result from extension of the inflammation to surrounding parts. Disease of the frontal or ethmoidal cells may lead to osteomyelitis of the frontal bone, meningitis, abscess in the frontal lobe, orbital abscess, or diffuse orbital cellulitis. Sphenoidal and posterior ethmoidal suppurations are fertile in complications. Optic neuritis and atrophy are caused by pressure on the chiasma or nerve; the sphenoidal sinus of one side may be so large as to involve the opposite nerve; the oculomotor nerves may also be affected, and pressure on Meckel's ganglion may produce severe neuralgia. Other complications are meningitis, cerebral abscess, thrombosis of the cavernous sinus, and erosion of the internal carotid artery. Septicæmia and pyæmia are occasional results of sinus suppuration.

The **diagnosis** is made by observing the pus in the nose and following it up to its source. A localized streak of pus, which reappears after wiping away, is a conclusive sign of disease of an accessory sinus. If the pus appear in the middle meatus, from under the concavity of

the middle turbinal, it must come from the antrum, frontal sinus, or anterior ethmoidal cells; whereas if it appear in the superior meatus, coming down through the olfactory cleft between the middle turbinal and the septum, it must proceed from the sphenoidal sinus or posterior ethmoidal cells (Fig. 697). This distinction is often very clear on posterior rhinoscopy, when the pus is seen within the choana lying either below or above the extremity of the middle turbinal. In addition to the presence of pus, there is swelling, often very marked, of the region where the discharge collects; thus the unciform process is often so swollen in disease of the anterior group

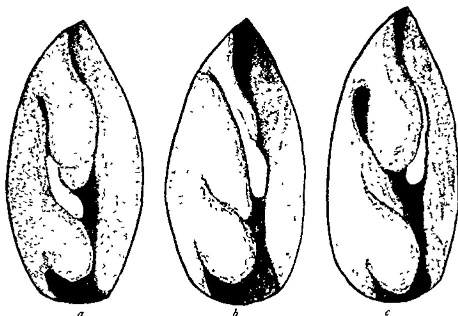


Fig. 697.—Discharge of pus from sinuses.

a, b, Pus discharged from the anterior group of sinuses and appearing below the middle turbinal; in *b* the hiatus semilunaris is swollen and partially hides the middle turbinal *c,* Pus appearing above the middle turbinal from the posterior sinuses.

as to conceal the middle turbinal, in which case it may be thought that the pus comes from above the latter body, but retraction of the œdematous tissue with a probe will make the true condition clear (Fig. 697, *b*). If, now, the pus is seen beneath the middle turbinal, we must determine or exclude suppuration in the frontal sinus and antrum respectively. Pus from the antrum is discharged more freely on stooping, and, if the head be bent well forwards with the suspected side uppermost, the discharge will pour out rapidly (Fraenkel's sign), whereas the frontal sinus empties itself best in the upright position. Suppuration in the frontal sinus can be determined by passing a probe along the infundibulum into the cavity, when pus trickles down along the instrument, or by

using a fine flexible cannula and blowing out the pus with an inflating ball. The passage of the probe is anatomically impossible in some cases, but in a number of these it can easily be effected after amputation of the anterior end of the middle turbinal. A fine flexible instrument is used, and bent to nearly a right angle for the terminal ¾ in ; it is passed in a forward and upward direction from the upper end of the hiatus semilunaris, and no force whatever must be used. The antrum is best explored by tapping it with a straight Lichtwitz's trocar. This is passed from the inferior meatus as high as possible beneath the attachment of the inferior turbinal, and at least ½ in. behind its anterior extremity, and the cavity washed out, or its contents aspirated into an exploring syringe. The sphenoidal or posterior ethmoidal cells are affected when pus is seen in the superior meatus. Exploration of the sphenoidal sinus is effected by passing a probe through the natural orifice, or with very little force through the thin anterior wall; the ostium is situated near the upper and outer angle of the anterior wall, 2½ to 3½ in. from the anterior naris and in a line from the latter through the centre of the lower border of the middle turbinal, or at an angle of about 45° with the floor of the nose. In order to do this under ocular inspection it is necessary to remove the posterior half of the middle turbinal, and this should be done when the symptoms point strongly to disease of the posterior sinuses. A streak of pus may be present to serve as a guide, and on gentle palpation a probe will enter the cavity, and pus exude, often under considerable pressure; or a fine cannula may be employed, and the pus blown out or sucked into a syringe. The instrument should be bent slightly downwards at the tip in order to avoid injury to the roof of the sinus.

Transillumination (Plate 114) is of value as an accessory method. For the *antrum*, any tooth-plate having been removed, a small electric light is placed in the mouth in a darkened room. The cheeks are, of course, illuminated, but the light also passes through the antrum and shows as a crescentic area, the antral *tache*, below the lower lid; a pupil reflex is present, and, if the lid be drawn down, the lower part of the sclerotic can be seen illumined. There is also a lachrymal *tache* near the inner canthus where the light penetrates the lachrymal bone; this is especially bright after removal of the ethmoidal cells, but has no diagnostic value. In disease of the antrum the antral *tache*, pupil, and sclerotic of the affected side are dark; the opacity is not due to pus, but to thickening and hyperæmia of the mucous lining, for it remains after washing out the cavity, and only slowly disappears after the radical operation. Opacity is not conclusive of disease, for when the bony walls are thick the cavity is opaque and the two antra may

be unsymmetrical. On the other hand, a suppurating antrum is not necessarily absolutely opaque.

To transilluminate the *frontal sinus* a tube with a distal opening is placed over the lamp and applied in an upward, inward, and backward direction to the floor of the cavity as far as possible within the orbit. An areola of light diffused through the soft parts is always present and liable to cause confusion, but a large healthy sinus is clearly marked out by a glow on the forehead which is sharply defined and shows the crescentic outline of the cavity. Owing to the great variability of these sinuses, darkness is no conclusive proof of disease, but a very clear translucency is strong evidence of the absence of suppuration.

It will be seen that transillumination does not of itself afford definite proof, but it is of value as confirmatory evidence; and it is especially useful when there is a question of combined antral and frontal suppuration, to exclude disease of one or other cavity.

Skiagraphy, if the plate be carefully taken, affords valuable confirmatory evidence, especially as regards the frontal sinuses. If the sinus is suppurating, the cavity becomes more opaque and its outlines blurred. It is useful in conjunction with transillumination, for if the sinus appear dark by the latter method and yet is shown by skiagraphy [illegible] increased. [illegible] shape of th[illegible]

Treatment.—Of acute sinusitis in general, treatment consists in rest in bed, aperients, a light diet, and hourly inhalations of mentholized steam prepared by adding a few drops of a 25-per-cent. solution of menthol in spirit to a pint of hot water in the inhaler. A simple nasal lotion may be used to wash away discharge, and the local application of adrenalin by the surgeon may be tried in order to relieve the occlusion of the ostium and permit the escape of the pus.

Antral empyema, if recent, should be treated as above, and in addition the patient should lie on the side with the head low and the affected cavity uppermost, so as to give continuous drainage. If this should be unsuccessful the antrum is tapped and syringed out with warm boric or saline solution, and this should be repeated daily for three or four times and then at longer intervals until the discharge has ceased; the majority of recent cases, where the duration of the symptoms has not exceeded a fortnight, are to be cured by this method after six or eight tappings. For chronic empyema some more permanent form of drainage must be established. Alveolar drainage through a tooth socket is now less employed than formerly, and should be restricted to fairly early cases of probable dental origin; a sound tooth should on no account be sacrificed. A carious tooth, the 2nd

Transillumination.

The lamp is shown placed in the mouth and against the floor of both frontal sinuses The right antrum and frontal sinus are dark, the left clear. The light traversing the left antrum lights up the infra-orbital crescent, the pupil and, very faintly, the sclerotic The nasal and lachrymal *taches* show faintly on the right side, although the right antrum is opaque. Note the glow transmitted through the soft parts over the right frontal sinus, although the cavity of the sinus is quite dark.

PLATE 114.

bicuspid or the 1st or 2nd molar, is removed, and a large hole bored in a slightly inward direction into the antrum; this may be done under gas anæsthesia. A tube or plug is fitted into the hole and the cavity syringed out frequently. If a tube be used, septic particles enter the antrum from the mouth, and if it be plugged continuous drainage is not obtained. It is extremely difficult to decide when to remove the tube, and in many chronic cases it must remain indefinitely. After its removal the opening rapidly closes, and if the affection recur the patient is no better off than before the operation. It is far better to establish permanent drainage into the nose by free

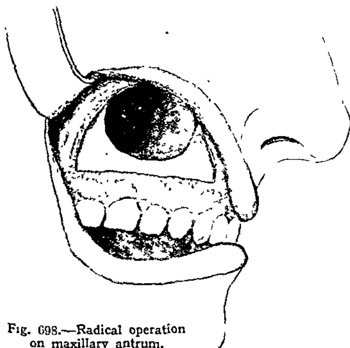


Fig. 698.—Radical operation on maxillary antrum.

removal of the antro-nasal wall. This may be done through the nostril by means of special knives or punch-forceps, but the operation more generally to be recommended is that of *Caldwell* and *Scanes Spicer* (Fig. 698). An incision is made in the gingivo-labial fold down to the bone from the canine to the 2nd molar tooth, and the periosteum raised over the canine fossa. A large opening is then made into the antrum, the cavity inspected, any polypi removed, and partitions broken down; but the mucous membrane should be respected as much as possible, as it is by its regeneration that healing finally occurs. An opening is made into the nose, and the greater part of the antro-nasal wall removed with punch-forceps. That part of the inferior turbinal which crosses the opening is necessarily

removed, but the anterior end should be left, unless it obstructs respiration. No packing is employed, and sutures are unnecessary. The after-treatment consists merely in washing out the nose and in some cases in syringing with a curved cannula passed through the nostril into the antrum, which the patient can easily learn to introduce. The symptoms are immediately relieved, but some discharge persists until the surface of the cavity has completely healed over, which may take several months. The antrum should never be drained through the canine fossa, or a permanent fistula is likely to result.

Frontal sinusitis.—The ostium being well placed for drainage, many acute cases recover spontaneously, or with the simple treatment already mentioned. In addition, the anterior end of the middle turbinal should be amputated to remove any hindrance to the discharge.

The treatment of chronic cases, and of those recent cases which fail to recover under simple treatment, may be by intranasal methods or by external operation. The extensive external operations which were at one time the routine method were found to be not sufficiently successful to justify their severity or the disfigurement which resulted, and intranasal methods are now generally employed in the first instance. The anterior end of the middle turbinal is removed if at all likely to interfere with drainage, and the anterior ethmoidal cells, which are always involved in suppuration of the frontal sinus, are thoroughly opened up, including the group called the "agger cells" in front of the infundibulum; a special rasp is then passed through the frontal ostium and the opening enlarged by filing away in a downward and forward direction the thick bony projection formed by the nasal process of the frontal bone. Through this enlarged opening a cannula can easily be passed, and the cavity regularly washed out. This method may be relied upon to relieve all severe symptoms, and to maintain drainage long enough to cure recent disease; but in cases of longstanding suppuration some discharge usually persists, and the enlarged opening tends eventually to contract. In these cases a better prospect of cure is offered by an *external operation,* which is essential when signs of external inflammation are present; the operation recommended is less extensive than Killian's method of obliteration. An incision is made along the supraorbital margin, its inner limb curving downwards along the side of the nose over the nasal process of the superior maxilla. The sinus is opened through the bony floor, which is entirely removed, together with the mucous membrane of the inferior or horizontal part of the sinus. The fronto-nasal duct is enlarged from above downwards into the nose, and the anterior ethmoidal cells are thoroughly removed, which is easily done after cutting through the nasal process of the superior maxilla. The incision may

be sutured with safety, as free nasal drainage has been established. Some surgeons pass a drainage-tube from the sinus into the nose and secure it by a stitch to the ala.

Ethmoidal disease.—Suppuration in the most anterior cells is usually a complication of frontal sinusitis, and is dealt with as part of the treatment of that affection. Localized suppuration in the anterior cells is to be treated by following up the pus with a probe and removal



Fig. 699.—External deformity resulting from ethmoidal mucocele.

of the bony walls with punch-forceps. Extensive disease is frequently associated with inveterate polypi, and is treated by thorough curetting under anæsthesia. The posterior group of cells is treated in a similar manner, with or without removal of the middle turbinal. Cases complicated by orbital swelling should be attacked through an incision similar to that for frontal sinusitis and by removal of the upper part of the nasal process and the inner orbital wall.

Sphenoidal-sinus disease.—The posterior part of the middle turbinal is first removed. The natural orifice is then enlarged, or an opening made through the anterior wall with a fine sliding punch or a small sharp spoon, the edges of which are directed downwards. The opening is enlarged freely in the downward direction with a larger punch.

This opening shows a marked tendency to contract, and must be kept patent, if necessary, by further use of the punch-forceps. No attempt should be made to curette the cavity or to interfere with any but the anterior wall.

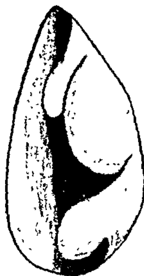


Fig. 700.—Left naris of patient shown in Fig. 699.

The ethmoidal mucocele caused a rounded swelling between the middle and inferior turbinals

MUCOCELES

Mucoceles are cystic dilatations of the accessory cavities, and are found in the antrum, frontal and ethmoidal sinuses. Some of those occurring in the antrum are probably cystic odontomas, but the others appear to be cysts formed from the glands of the mucous lining; it is unlikely that they result from blocking of the ostium and filling of the cavity with its normal secretion. They cause a slow globular distension of the affected sinus. In antral mucocele there are bulging of the nasal wall into the nose, prominence of the facial wall, depression of the hard palate, upward displacement of the eye, and epiphora; when the frontal sinus is affected there is expansion of its floor and anterior wall, and ethmoidal mucocele produces a bulging of the inner orbital wall (Figs. 699, 700). The bone is gradually absorbed and the swelling becomes elastic; egg-shell crackling can sometimes be obtained. There is great increase of translucency on transillumination. These cases do well after free drainage into the nose has been established by an operation similar to those described above for suppurative disease.

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THE PHARYNX, NASO-PHARYNX, AND LARYNX; AND EAR

BY NORMAN PATTERSON, F.R.C.S.

I. THE PHARYNX, NASO-PHARYNX, AND LARYNX

METHODS OF EXAMINATION

FOR examination of these regions a forehead mirror and a steady source

lamp

niner

nour.

well

gums

—buccal and lingual surfaces—tongue, floor of the mouth, and hard palate carefully examined. Any interference with the mobility of the tongue should be noticed. The movements of the soft palate are observed while the patient says "Ah." In order to examine the lower region of the buccal pharynx and the tonsils a tongue-depressor is necessary. The tonsils are best examined by looking across the mouth, the surgeon first of all retracting the angle of the mouth on the side opposite to the tonsil to be inspected. In this way a surface view is obtained and the crypts can be more easily examined with a probe. A good view of the tonsil may be obtained by pulling the anterior pillar forwards with a small blunt hook. Lastly, firm

probe; anæsthetic or hyperæsthetic areas may thus be discovered in the pharynx. In the case of an ulcer, tumour, or foreign body in the mouth and pharynx, valuable information may be gained by palpation.

Posterior

of the patient by

light so that it is

postnasal mirror, and introduce the tongue-depressor so that its proximal end rests on the lower front incisors and its distal end reaches nearly to the soft palate, then depress the tongue from the tip to the base. The pressure must be very gradual and free from all jerky movements. The mirror is now introduced to one side of the uvula past the free margin of the soft palate. Its reflecting surface looks forwards and upwards, and the following structures should be brought into view, viz. the posterior edge of the septum, the posterior ends of the superior, middle, and inferior turbinates, the last-named often being concealed by the soft palate. The septum is nearly

Symptoms and signs.—In the early stages the mucous membrane of the pharynx is swollen, congested, and dry, but soon it becomes covered with muco-purulent secretion. The temperature may reach 102° F. General malaise and headaches are complained of, and swallowing becomes intensely painful.

Treatment.—The patient should be confined to bed and 2 or 3 gr. of calomel administered, followed if necessary by a saline purge. Salicylate of soda in 10-grain doses every four hours generally proves beneficial. Aspirin should be given if the headache is severe. During the acute stages the patient should be kept on a fluid diet. Little can be done by local treatment, but relief is obtained by freely spraying the throat with a weak solution of bicarbonate of soda. When the attack is over, any predisposing condition, such as septic teeth or tonsils, should be dealt with.

CHRONIC PHARYNGITIS

Chronic inflammation of the pharynx may result from one or more attacks of the acute form, over-use or improper use of the voice; living in a dusty atmosphere; nasal disease; any condition, such as bronchitis, which causes repeated coughing and expectoration; anæmia, plethora, alcohol, tobacco, indigestion, constipation, gout, rheumatism, circulatory and renal diseases, diabetes. Residence in wet, changeable climates predisposes to the condition.

In the early stages of the disease there is hyperplasia; later this is followed by atrophy.

The following **varieties** are described: (*a*) *Catarrhal*, in which there is general congestion; (*b*) *granular*, in which the posterior pharyngeal wall presents numerous hypertrophied lymph-follicles; (*c*) *lateral*, where a fold of hypertrophied tissue occurs behind the posterior faucial pillars; (*d*) *atrophic*, where the tissues of the pharynx are shrunken, the mucous membrane is pale, dry and glistening, and in aggravated cases covered with crusts of inspissated mucus, a condition which is frequently associated with atrophic rhinitis.

Symptoms.—These include discomfort, sometimes pain on swallowing, the sensation of a foreign body which gives rise to constant hawking and coughing, weakness of the voice and hoarseness when laryngitis is present. Deafness may result from extension of the catarrh to the Eustachian tubes.

Treatment.—Any general condition such as constipation or anæmia must be treated, and the patient removed to healthy surroundings. A suitable diet should be prescribed, and alcohol and tobacco forbidden. Abnormalities of the nose or diseases of the accessory sinuses must receive attention. In some cases voice-rest

will be necessary. The pharynx should be frequently sprayed with an alkaline lotion. It may be painted with Mandl's solution or with 25-per-cent. argyrol. Cautious applications of the cautery in granular and lateral pharyngitis sometimes prove useful. Only a few granules are treated at one sitting, and the cautery is applied very superficially. As a substitute for the actual cautery, chromic acid or silver nitrate may be employed, fused on a probe When crusts are present they should be loosened by the application of an ointment or the use of a paroleine spray.

ACUTE SEPTIC INFLAMMATION OF THE THROAT

This condition varies greatly according to the site of the infection, the direction of its spread, the resistance of the patient, and the virulence of the poison. The infecting organism is nearly always the streptococcus.

The inflammation may remain superficial (hospital sore throat). In other cases œdema of the mucous membrane or cellular tissues, suppuration, or even gangrene occurs. The site of inoculation may be anywhere in the mouth, pharynx, or larynx. The onset may be gradual, or the condition may begin suddenly with a rigor. Sometimes a state of great prostration rapidly develops High temperature is usual, perhaps reaching 106° F, but occasionally the temperature is subnormal Dysphagia is sometimes pronounced, and, if the larynx is involved, dyspnœa may be so severe as to call for tracheotomy. Extension downwards causes involvement of the structures in the neck; upward extension sometimes leads to meningitis Delirium and coma may result. In other cases the cerebral symptoms are caused by general toxæmia. Death may occur in twenty-four hours. The mucous membrane of the parts involved becomes swollen and purple in colour. Great swelling of the uvula, soft palate, tonsils, or the structures around the upper laryngeal aperture may occur. In some cases extensive sloughing takes place. In cases associated with infiltration in the floor of the mouth, abscess-formation is likely to result, and the tongue becomes pushed upwards. Swelling may appear in the submental and submaxillary regions (angina Ludovici). The urine sometimes contains albumin and sugar. Bacteriological examinations should be made early when possible. If an abscess can be found and opened, recovery is often speedy. The prognosis depends more upon the general condition of the patient than upon the extent of the local mischief.

Treatment.—The patient should be confined to bed and given a diet of fluids and semi-solids. Alcohol, iron, quinine and strychnine may be called for. A hot compress applied to the neck gives relief. Polyvalent antistreptococcal serum should be administered early

and repeated if necessary. A free incision must be made if abscess-formation is present or suspected.

HERPES, ETC.

Herpes occurs as herpes febrilis or as herpes zoster. It has generally reached the stage of ulceration by the time an examination is made, as the vesicles quickly disappear. Herpes zoster is unilateral, whereas herpes febrilis has a wider distribution.

Pemphigus may occur with or without associated skin lesions.

Angioneurotic œdema, if it affects the larynx, may call for tracheotomy.

RETROPHARYNGEAL ABSCESS

In this condition, most often met with in infants, a collection of pus forms between the pharyngeal mucous membrane and the anterior surface of the cervical vertebræ. The abscess may originate in one of the retropharyngeal glands, in the connective tissue, or underneath the periosteum as the result of spinal caries. It may be acute or chronic. The *acute* form (*see also* p. 180) is generally due to infection from the pharynx, it is sometimes a complication of the acute specific fevers. Trauma is occasionally responsible. The *chronic* form is the result of tuberculous infection of a retropharyngeal gland or glands, and is often associated with tuberculous enlargement of the cervical glands; in rare instances it is due to caries of the cervical spine.

The **symptoms** vary with the type of infection. In *acute cases* the temperature ranges from 102° to 104° F., and the rise is possibly associated with a rigor. Dysphagia and dyspnœa develop, regurgitation of food occurs, and the little patient soon becomes wasted. Cough may be troublesome, and a characteristic cry has been described. The neck is often held stiffly In the *chronic* cases the symptoms are slow in development, and there may be no pain or pyrexia. Examination of the pharynx reveals a uniform swelling, generally more prominent on one side of the middle line It is usually soft and fluctuating, but if due to an enlarged gland which has not yet broken down it will be elastic. The abscess may extend in various directions, and asphyxia or pneumonia sometimes results from rupture into the pharynx.

Treatment.—Acute abscesses are generally opened through the mouth. The child is lightly anæsthetized and its head is extended over the end of the table. The abscess is opened with a scalpel or sinus forceps, and as the pus escapes it is rapidly mopped away. It is well in the case of large abscesses to aspirate before incising. All cases of tuberculous abscess, whether originating in caries of the spine or in the glands, should be opened through an incision made along the posterior border of the sterno-mastoid. Through this in-

cision it is quite possible, and often advisable, to remove the diseased retropharyngeal gland or glands. Afterwards the wound should be closed, but it may break down and require drainage. In some cases it is best to open even an acute abscess through an external incision.

ACUTE TONSILLITIS

This is an affection most often met with in early adult life; it is not common in young children The condition may be confined to the tonsils; at times it is associated with one of the infectious fevers, influenza, or syphilis. Arthritis is sometimes a complication, and the same organism may be discovered in the tonsils and in the joints (so-called rheumatic tonsillitis).

The following **varieties** are distinguished: (*a*) *Superficial* tonsillitis, where the surface of the tonsil is affected; (*b*) *follicular* tonsillitis, where the crypts become filled with an exudate consisting mainly of cast-off cells and bacteria; (*c*) *parenchymatous* tonsillitis, where the lymphatic elements of the tonsil are mainly involved. These three conditions are often combined. A fourth form (*d*) is that associated with *suppuration*, which generally occurs outside the tonsil (*peritonsillar abscess* or *quinsy*); rarely the abscess occurs within the substance of the tonsil. (*See* p 294)

Examination of the throat shows enlargement and congestion of the tonsils, and in severe cases the palate and uvula are inflamed and œdematous. The crypts, if they are involved, become filled with plugs of yellow or dirty white débris. In some cases a distinct membrane occupies the surface of the tonsil The cervical glands are generally swollen and tender. The chief symptoms are anorexia, malaise, pain shooting to the ears, especially severe on swallowing, and throbbing in character when an abscess is present, headache, pain in the back and limbs. The breath may be offensive, and the voice feeble and smothered owing to the swelling and to the accumulation of mucus. The attacks last from a few days to a week or more.

Diagnosis.—The disease is apt to be confounded with *diphtheria*. The main points of difference are: In diphtheria the temperature rarely exceeds 101° F., whereas in tonsillitis it may reach 104° F. In diphtheria there is less pain, the mouth is opened more easily, the membrane tends to spread to the soft palate, faucial pillars, larynx, naso-pharynx, and nose; albuminuria is frequent; infants are commonly affected, and examination of a swab or piece of membrane will reveal the presence of the Klebs-Löffler bacillus. If the diagnosis is in doubt, diphtheria antitoxin should be administered. Acute tonsillitis may also be mistaken for scarlet fever, secondary syphilis, and other diseases.

Treatment consists in keeping the *patient in bed and* administering a purge—calomel followed by a saline answers very well. The diet should *consist of fluids or semi-solids.* Large doses of salicylate of soda should be given, and later tincture of the perchloride of iron *in 30- to 40*-minim doses. The mouth and pharynx should be kept clean by spraying with an alkaline lotion. Applications of 2-per-cent. izal are most beneficial.

PERITONSILLAR ABSCESS

In this condition an abscess forms in the tissues immediately outside the upper part of the tonsil. The disease is at first unilateral, but frequently, *as one side is clearing up, the other side becomes* affected. A smooth red swelling forms above and outside the tonsil, *displacing that structure inwards and downwards and causing swell*ing of the palate and uvula, which is pushed over to the opposite side. The **symptoms**, except that they are usually referred to one side, resemble those of acute tonsillitis The pain on swallowing is greater and, as pus accumulates, the patient experiences more difficulty in opening the mouth and in protruding the tongue. Complications are rare, but fatal cases have been recorded. Spontaneous rupture may occur with instant relief. The **treatment** in the early stages is similar to that employed in acute tonsillitis. In addition to general treatment, frequent spraying with a warm alkaline lotion and the application of heat externally will give relief. After the *fourth day pus is generally present*, and there should be no delay in opening the abscess A special pair of sinus forceps is the best *instrument to employ. The puncture is generally made* at a point midway between the base of the uvula and the last upper molar, or through *the area where the abscess is pointing The closed* blades of the forceps are thrust directly backwards till the abscess is reached, and then the blades are opened and *rapidly withdrawn.* Sometimes the surgeon fails to open the abscess at the first puncture, and a second exploration is necessary. When the patient has completely recovered, it is generally advisable to enucleate the tonsils.

MEMBRANOUS SORE THROAT

Non-diphtheritic membranous and ulcerative sore throat may be caused by a number of organisms. Those most commonly found are the *Spirochæta denticola* and *Bacillus fusiformis*, giving rise, together, to so-called **Vincent's angina.** Ulceration accompanied by membranous formation occurs on the tonsil, and there is associated *involvement* of the gums. The disease is more common in children, but it was met with very frequently in soldiers during the war. Both the *organisms* which are held to be responsible for the condition are

Gram-negative; they are best demonstrated in film preparations. Dental sepsis is usually present, and the lesions may be entirely confined to the gums. The glands on the corresponding side are swollen. Occasionally the ulceration spreads to the pharynx, cheek, or tongue, and in rare instances to the larynx. The **symptoms** resemble those of tonsillitis, but the condition is generally unilateral and the temperature rarely exceeds 101° F. Recovery generally takes place in from one to three weeks Fatal cases have been recorded. **Treatment** consists in the use of cleansing lotions. Various local applications have been recommended. They include tincture of iodine, powdered methylene-blue, alkaline solution of salvarsan, and vinum ipecacuanhæ combined with liquor arsenicalis. When the patient has recovered, attention must be given to the teeth; tonsils and adenoids may call for removal. The disease is liable to be mistaken for diphtheria or tertiary syphilis.

KERATOSIS PHARYNGIS

Yellowish or whitish horny outgrowths appear scattered over the tonsils, and the lingual tonsil is usually involved in the process. The condition may also affect the posterior pharyngeal wall, naso-pharynx and, very rarely, the larynx. Beyond discomfort, there are generally no symptoms. Apart from attention to the general health and informing the patient that the condition is not a serious one, no treatment is advisable. Calculi and cysts are occasionally met with in the tonsillar region, and a mistaken diagnosis in not uncommon.

CHRONIC ENLARGEMENT OF THE FAUCIAL AND OF THE PHARYNGEAL TONSILS (ADENOIDS)

Chronic enlargement of the faucial tonsils is much more common in children, and is nearly always associated with hypertrophy of the naso-pharyngeal lymphatic tissue. Adenoids are sometimes present at birth; they tend to atrophy about puberty, but in rare instances they have been discovered in patients over 50. Frequently no cause can be found, but enlargement of the tonsils and adenoids may follow one of the specific fevers, repeated attacks of acute tonsillitis, or tuberculous infection The last condition is usually associated with enlargement of the cervical glands. Chronic hypertrophy of the tonsils is far more frequent in damp climates, and it tends to run in families. The lymphoid tissue of the tonsil (parenchymatous tonsillitis), the follicles (follicular tonsillitis), or the connective tissue (fibrous tonsillitis) may be the main seat of the chronic inflammatory changes. When fibroid degeneration occurs the mouths of the crypts tend to become obstructed, and this leads to retention of débris, and possibly to abscess-formation. Such an abscess may

be situated deeply, close to the capsule, and will only be discovered when the tonsil is examined after removal. It is obvious that the shrunken, fibroid tonsil is very likely to give rise to trouble from septic absorption. The tonsillar recess, situated in the upper part of the tonsil, may also contain septic cheesy material or pus (*see* p. 287). Very similar changes to the above may occur in the naso-pharyngeal tonsil.

The **symptoms** for which the adenoids are mainly responsible include general ill-health, defective growth, more especially mal-development of the chest, loss of memory, slow cerebration, headaches, inability to fix the attention, mental and bodily fatigue, thickness of the voice, Eustachian and middle-ear catarrh, leading to deafness; acute and chronic middle-ear suppuration, inefficient nasal respiration, causing mouth-breathing and snoring, disturbed sleep and night terrors. Septic tonsils may give rise to fetid breath, and absorption from them may be the cause of symptoms indistinguishable from acute or chronic rheumatism. Examination of the nose may show marked narrowing of the nasal apertures, expansion of the root of the nose, congestion of the turbinates. In severe cases the mouth is open, the upper lip retracted and the folds around the mouth obliterated, and thus the natural play of the facial muscles is interfered with, leading to the dull, stupid, expressionless countenance associated with adenoids. The upper teeth no longer form a horseshoe curve but a V, the upper incisors overlapping the lower and failing to meet them when the jaws are brought together (" open bite "). The teeth become irregular and crowded together, and show early caries, and the gums are inflamed. The palate is high and narrow. Enlargement of the cervical glands in both anterior and posterior triangles may be present. If the tonsils are enlarged as well as the adenoids, the respiratory difficulties are increased.

Treatment.—It is not necessary to operate on all cases of enlarged tonsils and adenoids. If the hypertrophy is moderate and gives rise to no symptoms, and more especially if the patient is approaching the age of puberty, when atrophy may occur, he should, when possible, be placed in the most favourable surroundings, and breathing exercises should be systematically carried out. When the tonsils are obstructing the pharynx and accompanied by a mass of adenoids, operation is necessary. Septic tonsils, whether or not associated with enlargement of the cervical glands, general ill-health, pain in the joints, or elevation of temperature, should be removed. Catarrhal or suppurative otitis media, and maldevelopment of the jaws and chest, are indications for operation. It is customary to remove the whole tonsil, including its capsule. Tonsillotomy is now practised but seldom. In children *complete enucleation of the tonsils* can,

in most cases, be accomplished with the guillotine. It is only in exceptional cases, and in most adult patients, that formal dissection is necessary. The method employed varies a great deal with the operator and anæsthetist, and the time at their disposal. The technique which is possible in a nursing home is, unfortunately, quite unsuitable for a busy out-patient department The following method will be found suitable where time is an important consideration.

The patient is anæsthetized with ether or C.E. mixture, a moderate degree of narcosis being aimed at. When this is reached he is placed as near the right-hand edge of the table as possible, and the gag is introduced on the left-hand side of the mouth, and then moderately opened (Fig. 703). The head is now rotated so that it faces the operator, who stands on the patient's right-hand side. Heath's modification of Mackenzie's guillotine is probably the most satisfactory pattern. The right tonsil is first removed. The operator holds the guillotine in the right hand and introduces it in the reversed way, the sliding blade being next the tonsil to be removed, and the handle pointing backwards and to the patient's left. During introduction the tongue may be depressed with the forefinger of the left hand, or with the blade of the guillotine. When the guillotine is in position the free portion of the tonsil projects through the ring, and the cutting blade slopes very obliquely across the mouth. [illegible]

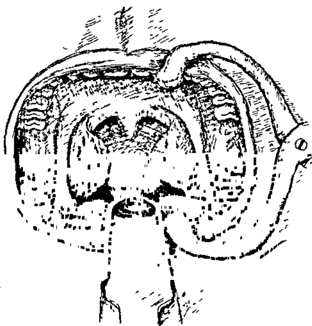
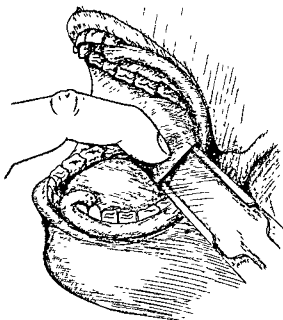


Fig. 703.—Enucleation of the tonsils with the guillotine. Preliminary stage.

[illegible] pushed [illegible] (Figs. [illegible] ed by exerting firm pressure on the blade and combining a pull with a movement of rotation. In order to remove the left tonsil the procedure is reversed, the guillotine being held in the left hand and the right forefinger

being used to press on the anterior pillar. If the hæmorrhage is brisk it is well to apply pressure to the fossæ, left after removal of the tonsils, for five to ten minutes. In children it is rarely necessary to tie any vessels.

Occasionally it is impossible to dislocate the tonsil through the ring of the guillotine, and resort must be had to dissection. This is the best method to adopt in most adults; when the tonsils are fibrous; when adhesions are present as the result of a previous attack of quinsy; or if for any reason hæmorrhage is likely to be excessive. The guillotine operation is more rapid, requires a lighter degree of anæsthesia, causes less trauma, and is followed, therefore, by a more speedy recovery.



g. 704.—Enucleation of the right tonsil with the guillotine. Dislocation of the tonsil by digital pressure applied over the anterior pillar.

For *dissection* it is very important to have as an associate an anæsthetist accustomed to such operations. The most convenient position in which to have the patient is on his back, with the head well extended. This is best accomplished by placing a small sandbag or rolled-up bath towel under the patient's shoulders. A comparatively deep anæsthesia is necessary, but with the patient in the position described it is possible entirely to prevent the passage of blood into the air-passages. A gag is introduced and the tongue held forward with a clip. The mucous membrane close to the upper pole of the tonsil is carefully divided with scissors or a blunt dissector, and the capsule exposed. The tonsil, with its capsule, is now pulled inwards, and by blunt dissection it is separated from the pharyngeal wall. When the lower pole is reached it is freed from the lingual tonsil. The wound must be kept dry by repeated sponging or by a mechanical aspirator, which, when it is available, is more efficient and causes less trauma. Any bleeding vessels are clamped and ligatures applied. If general oozing is present, firm pressure for five to ten minutes will generally be effective. Both fossæ can be compressed at the same time by introducing forceps, armed with gauze pads, from opposite angles of the mouth, so that the forceps cross about the centre of the mouth. Only very occasionally will it be necessary to suture the pillars.

The adenoids are removed by introducing a special curette behind the soft palate. The cutting blade of the instrument is pressed forwards and upwards against the highest portion of the vomer, and then swept backwards and downwards, following the curvature of the roof of the pharynx, firm pressure being applied all the time. Thus the adenoid tissue is cut through

close to its attachment, or even removed with some underlying fibrous tissue. The instrument should be introduced two or three times until all lymphoid material has been removed, and special attention must be given to any accumulations in the neighbourhood of the Eustachian tubes. Finally, a small curette is introduced by way of the naso-pharynx into the upper region of the posterior nares on each side. In this way the most anterior portion of the adenoid mass is removed. It is now customary in some clinics to carry out removal of tonsils under local infiltration anæsthesia (for technique, *see* Vol. I., p 731)

After-treatment.—The diet for the first twenty-four hours should be fluid or semi-solid, and for the first week the patient should

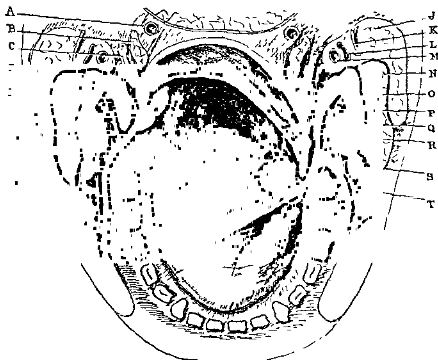


Fig. 705—Transverse section above the tonsil showing some of the relationships.

frequently cleanse the mouth and pharynx with a mild antiseptic lotion. It is well to give an aperient on the night following the operation. Hæmorrhage, if slight, is treated by giving the patient an injection of morphia and propping him up in bed. It is not uncommon to find the tonsillar fossa occupied by a bloodclot, beneath

which vigorous oozing occurs. Frequently the hæmorrhage stops if the clot is removed. When bleeding is severe, and a definite bleeding-point can be discerned, it should be clamped and ligatured. If the necessary instruments are not at hand, steady continued pressure from the inside and counter-pressure behind the angle of the jaw will control the bleeding in nearly every case.

In **Hodgkin's disease** (lymphadenoma) the tonsillar enlargement is *merely a local manifestation of a grave general condition.* (*See* p. 183.)

BENIGN TUMOURS OF THE PHARYNX

Those met with are papilloma, fibroma, adenoma, lipoma, angioma, cysts (including dermoids), and growths resembling parotid tumours. **Papillomas** are usually small and pedunculated, presenting a granular surface. If small they are easily overlooked, as their colour resembles that of the mucous membrane. **Adenomas** usually occur in the palate; they sometimes grow to large dimensions. **Lipomas** generally occupy the soft palate. Rarely they originate behind the posterior pharyngeal wall. **Dermoid cysts** are rarely met with, except in children who die at birth or soon afterwards. **Angiomas** are rare. Sometimes they grow to a great size. **Parotid - like tumours** are sometimes classified as endotheliomas, but they are innocent and remain local Frequently these tumours arise in the tissues outside the pharynx and displace the tonsil. They may give rise to a swelling in the neck.

Treatment.—Many cases can be left alone. *Difficulty may be* experienced in removing large tumours. Angiomas are probably best treated by diathermy. Certain tumours must be dealt with through an incision in the neck.

MALIGNANT TUMOURS OF THE PHARYNX

Of **sarcomas**, *the round and spindle-shaped varieties* are the commonest, but nearly every type may occur. The tonsil is the most usual site. In sarcoma of the tonsil and pharynx the cervical glands are generally *early involved.* The tumour has a smooth rounded appearance; later, ulceration takes place. Sometimes a sarcoma is very soft. An epithelioma is always very hard.

A *peculiar growth*—**fibro-sarcoma**—arises in the naso-pharynx. It occurs chiefly in males between the ages of 15 and 23, and if untreated may assume enormous proportions. By absorption of the superior maxilla it may cause great disfigurement, and eventually it may lead to the death of the patient. Such a tumour must be distinguished from a polypus originating in the nose and passing back into the naso-pharynx.

Carcinoma

If we except the variety which is met with in the retrocricoid region, which is a tumour almost peculiar to young women, cancer of the pharynx, tonsil, and posterior third of the tongue occurs almost exclusively in men, who are generally past middle life. It originates as a wart-like growth of almost cartilaginous hardness. Generally as it increases in size the centre ulcerates, but the edge always remains characteristically hard. Some growths tend to spread superficially, others to penetrate deeply. Growths on the palate frequently remain superficial. Tonsillar growths are apt to penetrate, and those attacking the anterior pillar sometimes burrow beneath the tonsil, and give rise to a deep ulcer which undermines that structure. Occasionally tumours of considerable size are present without any palpable glandular enlargement, but the glands are generally involved early, and not infrequently a small primary growth is associated with an enormous tumour in the neck. The glands in both anterior and posterior triangles and in the substerno-mastoid area are frequently involved. The **symptoms** include pain shooting up to the ear, increased salivation, fetid breath, dysphagia, dyspnœa, cachexia, hæmorrhage. Tumours may reach a considerable size before they give rise to any symptoms If the diagnosis is in doubt, it is best to remove a piece of the growth for microscopic examination.

Surgical treatment.—The character of the tumour, its size, situation, the extent to which the glands are involved, and the general condition of the patient are important factors in deciding whether or not an operation should be undertaken, and the nature of that operation. In every case of sarcoma or endothelioma, **radium** or **X-rays** (especially by the Erlangen method) should be first of all tried. Many of these tumours respond to radiotherapy in the most remarkable way. For all cancerous tumours involving the tonsil, palate, buccal pharynx, base of the tongue, epiglottis or aryteno-epiglottic fold, **diathermy** should be used in preference to a cutting operation. This treatment, when used for surgical purposes, consists in passing through the patient an electric current of very high frequency. Two electrodes are used: a small movable terminal, which is applied to the tumour and the tissues around it, and a large fixed plate, which is usually placed over the abdomen. Between the plate and the abdominal wall are interposed several layers of lint, or a folded towel, saturated with normal saline solution. Heat is developed in the neighbourhood of the small electrode; the fluids in the tissues are brought to boiling-point and bubbles appear. The tissues for some distance around the electrode are coagulated so that destruction spreads well beyond the point of application. The extent to which penetration takes place depends on the character

of the tissues, their vascularity, and the size of the electrode. Firm pressure with the electrode or ligation of the vessels supplying the part causes diminished vascularity and, therefore, increases the depth of penetration. If charring occurs at the seat of application the electrode acts as an ordinary cautery, and, for the time being, the advantages of diathermy are lost. As soon as charring occurs the electrode should be removed, cleaned, and a few drops of normal saline applied to the tissues under treatment. Whenever possible, it is better to excise the growth with the diathermic cautery knife and afterwards apply a button-shaped electrode all over the surface of the cavity left by the tumour. Frequently excision is impossible and the tumour has to be destroyed by plunging the electrode many times into its substance. *The surgeon should first of all destroy the tissues around* the carcinoma and gradually work towards its centre.

The main danger associated with diathermy is secondary hæmorrhage. This rarely occurs if a preliminary ligature of the main vessel or vessels of supply has previously been done. The chief advantages of diathermy over cutting operations are: (1) Absence of bleeding and, therefore, an uninterrupted view of the parts under treatment; (2) all malignant cells are destroyed, and therefore there is no possibility of recurrence taking place from implantation of these cells; (3) tumours in the neighbourhood of the base of the tongue and epiglottis and large tumours in the mouth and pharynx can be treated without approaching them from the neck—a procedure accompanied *by great risk; (4) the shock is much less and the operation mortality* is comparatively low; (5) the results with small growths are much better than those obtained after cutting operations; (6) a certain percentage of patients suffering from advanced "inoperable" carcinoma remain well for from one to six years after operation. (*See* Plate 115, Figs. 1, 2.)

The usual gland operations must be carried out in every instance, either at the same time as *the diathermy or at a later date; the* time chosen will depend on the site and size of the growth and the general condition of the patient. Occasionally the first operation is confined to removal of the glands.

Tumours of the pyriform fossæ and the arytenoids and hypopharynx are unsuitable for diathermy. A large number of such growths are inoperable. When it is considered that there is a reasonable prospect of removal, the plan of operation developed by Trotter—lateral transthyroid pharyngotomy—will be found to afford the best means of access. The description is somewhat complicated, and the reader is referred to Trotter's original paper (*see* Bibliography, p. 337). One of the main features of the operation consists in preparing an approach to the tumour by a preliminary

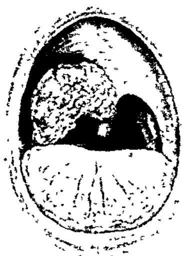


Fig 1.—Epithelioma of right tonsil and palate. (*Author's case*)

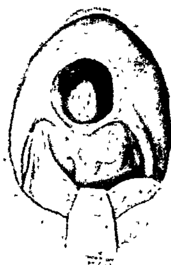


Fig. 2.—Same case as Fig 1 four years after treatment of primary growth by diathermy, with removal by dissection of cervical glands. Patient well and at work, and showing no signs of recurrence.

PLATE 115.

removal of the great cornu of the hyoid bone and the posterior two-thirds of the ala of the thyroid cartilage. Where it is necessary to excise considerable portions of the pharynx, the operation is commenced by planning suitable skin flaps which are used to make good the defect. Subsequently a plastic operation is carried out. In some cases it will be found necessary to remove the whole of the larynx as well as a portion of the pharynx (Gluck). Here again skin-flaps are made use of to replace the portions of the pharynx which have been cut away.

ACUTE LARYNGITIS

This disease often results from extension downwards of an acute catarrh. The causes are, therefore, very similar to those which give rise to rhinitis and pharyngitis. Occasionally acute laryngitis arises as a primary condition The **symptoms** are those of an acute cold accompanied by hoarseness and sometimes by aphonia. A painful cough is present in the early stages; when free secretion occurs the pain subsides. Examination shows congestion of the whole larynx; the vocal cords are red and swollen, occasionally presenting submucous hæmorrhages In children the condition may resemble diphtheria or the impaction of a foreign body in the larynx. Owing to the diminutive size of the larynx in children and the laxness of the mucous membrane, obstruction requiring tracheotomy or intubation sometimes occurs. The symptoms of laryngitis generally subside in from seven to ten days, but hoarseness may persist owing to paresis of the internal tensors. **Treatment** is on the same lines as that adopted in acute pharyngitis. Inhalations of compound tincture of benzoin are comforting. Alcohol and tobacco must be forbidden. In children showing signs of laryngeal obstruction a drachm of ipecacuanha wine will sometimes relieve urgent symptoms Singers must rest the voice for some considerable time. If the condition persists, a careful examination should be made for tuberculosis.

CHRONIC LARYNGITIS

Most of the causes which give rise to chronic pharyngitis may also be responsible for this condition. Chronic laryngitis may be associated with syphilis, tuberculosis, new growths, or a foreign body. Various forms are described. *Chronic catarrhal laryngitis* requires no special description. In *laryngitis sicca* bands of sticky mucus may be seen stretching between the cords, which in some cases are pale, in others congested. In aggravated cases, which are generally associated with atrophic rhinitis, crusts occupy the cavity of the larynx and even extend to the subglottic space and trachea (*crusted laryngitis*). A *hypertrophic* form is met with in which the ventricular

bands are swollen and hide the true cords from view, or an irregular mound projects from the interarytenoid region. Chronic laryngitis may resemble tubercle, lupus, syphilis, or malignant disease. The **treatment** is similar to that of chronic pharyngitis (p. 290). Any general cause must be treated. Vocal rest is important, and strict silence may have to be observed. If, in spite of ordinary remedies, the condition persists, it may be necessary to apply to the larynx astringents, such as chloride of zinc, 30 grains to the ounce.

Special Forms of Laryngitis

Nodular laryngitis results from over-use or faulty use of the voice, and gives rise to hoarseness. It is chiefly met with in female teachers and in singers, especially sopranos and tenors. The condition is generally unilateral at first, but later on both cords become affected. A small, firm nodule occurs on the edge of the cord at the junction of the anterior and middle thirds (Fig 706). **Treatment** must be directed to the general laryngitis which accompanies the condition. Voice-rest is essential, and later on lessons in voice-production. Removal of the nodule is called for in some cases Operation must be avoided, if possible, in professional singers

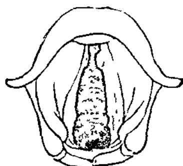


Fig. 706.—Singer's nodules. Larynx in quiet respiration Shows the nodules in usual situation on both cords.

Pachydermia laryngis.—In this condition one vocal process presents a swelling with a central depression, while the opposite vocal process is occupied by a conical projection which fits into the depression. Sometimes a swelling occupies the interarytenoid region. The etiology is obscure. Treatment is unsatisfactory. Unilateral cases may resemble malignant disease. **Chronic subglottic hyperplasia** is characterized by uniform swellings, generally symmetrical, situated below the cords. Dyspnœa, requiring tracheotomy, may develop.

INNOCENT TUMOURS OF THE LARYNX

Papilloma, fibroma, lipoma, chondroma, myxoma, and angioma may occur. Papilloma is much the commonest, and is met with in children; all the others are peculiar to adult life Men are more often affected than women. The symptoms, of which hoarseness, dyspnœa, and cough are the chief, depend on the size of the tumour and its attachments. The diagnosis is generally comparatively easy. In order to obtain a good view of the larynx in children the direct

method is often necessary. In elderly people it may be difficult to be certain that the growth is innocent.

Papillomas occur chiefly on the true and false cords. In children they are generally multiple and may fill the larynx. Pedunculated and sessile forms are met with. **Fibromas** generally spring from the cord. **Cysts** occur most frequently on the anterior surface of the epiglottis, but may occupy nearly any position in the larynx. **Angiomas**

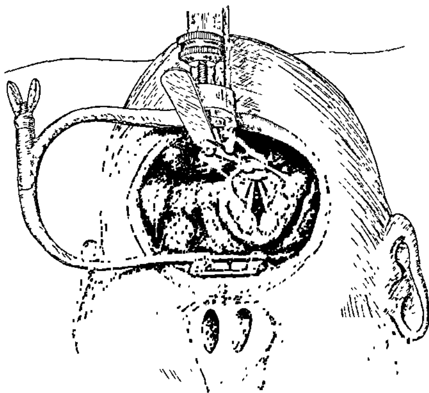


Fig. 707 —Suspension laryngoscopy. View obtained by the examiner.

are very uncommon. It is important, in view of treatment, to distinguish this tumour from a simple cyst.

Treatment.—When the tumours are so situated that they do not interfere with the function of the larynx, they may be left alone. In nearly all cases the growth can be removed *per vias naturales,* and in adults the indirect method can generally be adopted. The operator makes use of Mackenzie's forceps or one of the numerous modifications. The pharynx is brushed over with a 5-per-cent. solution of cocaine, and the larynx is thoroughly anæsthetized with a 10- to 20-per-cent. solution of the same drug; a rectangular applicator

is used. In irritable patients a course of bromides and an injection of morphia half an hour beforehand are useful The forceps are held in the right hand in removing a growth on the right cord. When the growth is on the left cord the left hand is used. Papillomas in children are best dealt with by the direct method. For the removal of innocent tumours the suspension apparatus devised by Killian, and modified by the writer, is ideal, and a good exposure of the larynx can generally be obtained (Fig. 707). When the tongue-depressor is in position, a long epiglottis-depressor is introduced over the laryngeal surface of the epiglottis, which holds this structure out of the way, so exposing the cavity of the larynx. The whole instrument is suspended from a gallows. One advantage of this instrument over the bronchoscope is that both hands are left free for manipulations. It is even possible to carry out dissections in the neighbourhood of the larynx, and large tumours may be removed (Fig. 708). A preliminary tracheotomy or laryngotomy is a wise precaution. In children with multiple papillomas it is advisable not to remove the tracheotomy tube, as subsequent operations are generally necessary For the removal of innocent laryngeal tumours external operations are seldom required. In a few cases the bronchoscope will be found more suitable than the suspension instrument.

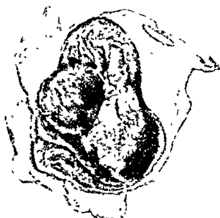


Fig. 708. — Cavernous angioma growing from the left pyriform fossa and aryepiglottic fold (*natural size*), removed by the author with the aid of suspension laryngoscopy.

MALIGNANT TUMOURS OF THE LARYNX

Carcinoma, nearly always of the squamous-celled variety, is comparatively common. Sarcoma is very rare. Carcinoma is much more frequent in men than in women. Cases are met with between the ages of 40 and 80, most commonly between 50 and 60. In rare instances the disease occurs in patients under 40. When the true cord, ventricular band, ventricle, or subglottic region is affected, the term "intrinsic cancer" is applied. When the epiglottis, aryepiglottic fold, or arytenoid is involved, the case is one of "extrinsic cancer." Cancer attacking the mucous membrane covering the posterior surface of the cricoid is often termed extrinsic, but it is

really a tumour of the hypopharynx. This particular growth is much more common in women.

Symptoms.—As the vocal cord is the most usual site of origin in intrinsic cancer, hoarseness is an early and important symptom. In extrinsic cancer there may be no symptoms at first, but as the tumour increases in size it gives rise to pain which often radiates to the ears, dysphagia, fetor of the breath, increased salivation, hæmorrhage, glandular enlargement, and cachexia. Dyspnœa may be present in either the intrinsic or the extrinsic variety. So long as the growth remains intrinsic, glandular enlargement does not occur.

Examination.—The laryngeal picture is a very varied one. There may be simple unilateral congestion and thickening of the cord, or it may present an uneven, granular surface. In other cases a white tumour, with finely divided [illegible] a papilloma, is attached to the co[illegible]r extending along the edge of the [illegible] a definite ulcer is present. The movements of the cord may be restricted. Other parts of the larynx may be the seat of a tumour. As the growth advances it ulcerates, and presents an irregular sloughing surface surrounded by an elevated margin. Perichondritis and œdema may develop, obscuring the growth from view. The diagnosis has to be made from chronic laryngitis, tuberculosis, syphilis, pachydermia, and simple neoplasm. A unilateral congestion, infiltration, or tumour occurring in a patient past middle age should be regarded with suspicion. If the movement of the cord is sluggish, there is still more ground for suspicion. In every case when sputum is obtainable it should be tested for the tubercle bacillus, and in some cases a Wassermann test proves useful, but it is as well to realize that a positive result does not negative the diagnosis of cancer It is better to be guided by the result of vigorous anti-syphilitic treatment than by the Wassermann reaction. A portion of the tumour may be removed for microscopic examination, but only after consent has been given for a subsequent operation should the growth prove to be malignant. *The specimen removed* should include a portion of the tissue from which the tumour is growing.

Prognosis.—In untreated intrinsic cancer the patient seldom lives more than three years. Extrinsic cases progress rapidly. In early intrinsic cases the prospects after operation are better than in cancer affecting any other region of the body, there being 70–80 per cent. of cures. How great, then, is the importance of early diagnosis.

Operations for intrinsic cancer.—The operation of **thyrotomy** is now seldom required except for the removal of intrinsic cancer. It is

performed in the following way, generally under chloroform anæsthesia, although it is possible to operate under a local anæsthetic. The usual attention must be given beforehand to the mouth and teeth. Before the operation begins the patient should be placed in the Trendelenburg position, with the head well extended, so that all blood and secretions may pass into the pharynx. *A median incision* is made, extending from the body of the hyoid to the suprasternal notch, and the soft structures are divided and retracted until the cartilages of the larynx and trachea are exposed to view. Of necessity the thyroid isthmus is severed. All bleeding-points are clamped. In order *to avoid spasm, 5–10 drops of a 2½-per-cent. solution* of cocaine may be injected into the trachea before opening it. The rings, about the third, fourth, and fifth, of the trachea are incised vertically, and a tracheotomy tube is inserted. The thyroid cartilage is next divided in the middle line with shears or a saw, and the *alæ held apart. It is now advisable to apply* a 5-per-cent. solution of cocaine and adrenalin to the laryngeal mucous membrane. A small tethered sponge is then introduced through the opening in the larynx and pressed downwards so that it lies just above the tracheotomy tube. The perichondrium, and with it the mucous membrane and growth, is separated from the underlying thyroid cartilage by an elevator, such as that employed in septal resection. Finally, the tumour is cut away with scissors, care being taken that at least half an inch of surrounding mucous membrane is removed with the growth. After all hæmorrhage has been arrested the sponge is removed, and the alæ of the thyroid are allowed to fall together, or are tacked together with a few sutures. The skin incision is now partially closed. The tracheotomy tube may be removed at the end of the operation or left in position for twenty-four hours. The patient should be propped up in bed as soon as possible.

An improvement on this method is the **partial or "window"-resection of the larynx**, introduced by Lambert Lack. The windpipe is exposed by the usual vertical incision, tracheotomy performed, the soft tissues are turned off *the ala of the thyroid on the affected side and the cartilage is* cut away, the upper and posterior edges only being left. Part of the cricoid cartilage may also be exposed and removed when necessary. The cavity of the larynx is opened in the median lin [illegible] with sufficient *margin of healthy tissue, freely cut away.* [illegible]
field of operation, renders the parts to [illegible]
makes the operation rapid and easy and more certainly complete, whilst hæmorrhage *is more easily controlled. The soft parts can be removed by* cutting from without inwards, and thus there is still less danger of blood entering the air-passages. Healing is more rapid, and the voice as good as after thyrotomy. Further, if the growth extends across the anterior commissure, by removing the overlying cartilage the larynx may be first opened from below the growth by cutting transversely through the crico-thyroid men[illegible] *without being* cut [illegible] ormed.

[illegible] d a fortnight or so before operation. The Trendelenburg position is adopted. A median incision is made extending *from the hyoid* bone to the suprasternal notch. From its upper extremity a transverse incision is carried outwards on each side as far as the anterior border of the sterno-mastoid. The vertical in- [illegible]

[illegible]

now separated from the sides of the larynx and [illegible]

tracheotomy tube is inserted. The larynx is now separated from its posterior

remove it from above downwards. The latter method has certain advantages.

LUPUS OF THE PHARYNX AND LARYNX

Is generally secondary to a similar infection in the nose. The usual pinkish nodules occur, followed by ulceration. The alveolar margins and hard palate may be affected, as well as the pharynx, naso-pharynx, and larynx. In the larynx a preference is shown for the epiglottis. Healing is apt to take place in one direction and extension in another. Great deformity of the pharynx and larynx may result.

Treatment.—Good food, fresh air, and sunshine are more important than local measures, which include curetting and treatment by the cautery and caustics. Arsenic in increasing doses has many advocates The disease, which is more common in females, is liable to be mistaken for syphilis, especially the congenital variety.

TUBERCULOSIS OF THE PHARYNX AND LARYNX

Acute miliary tuberculosis of the pharynx is a rare complication of phthisis; the tubercles soon break down, forming a multitude of small ulcers. Discrete ulcers of a much more chronic nature may also occur in the pharynx or on the tonsils. Invasion of the pharynx or larynx may be caused from contact of the infected sputum with the mucous membrane, or, more rarely, the disease may be carried by the blood-vessels or lymphatics. The bacillus may enter by way of a gland duct, or of an abrasion, or possibly may penetrate the normal mucous membrane. The posterior regions of the larynx are more frequently affected than the epiglottis. The changes met with include infiltration, ulceration, perichondritis, and necrosis of cartilage.

Symptoms.—Weakness of the voice, especially after use, is a characteristic symptom. It is due to the laryngeal lesions, which include infiltration of the muscles, but is also to some extent dependent on the pulmonary lesion and diminished expiratory blast. Aphonia sometimes precedes any visible lesion in the larynx. Cough may be present, with or without expectoration. Dyspnœa is uncommon, but in the later stage is sometimes so pronounced as to necessitate tracheotomy. Dysphagia is at times very distressing. Anæmia or

hyperæmia may be present in the larynx; it may be generalized or patchy. The soft palate is frequently very anæmic. Large pear-shaped, juicy-looking swellings of the arytenoids are common, and the epiglottis may show a similar swelling, the cords being completely hidden from view. Sometimes an irregular swelling forms in the interarytenoid region, followed later by ulceration. The vocal cords may be injected, swollen, granular-looking, ulcerated, or the seat of tumour-formations Ulceration may occur in the trachea and bronchi. Perichondritis is found most frequently in the region *of the crico-arytenoid joint.*

Diagnosis has to be made from simple chronic laryngitis, lupus, pachydermia, syphilis, innocent and malignant tumours. Senile tuberculosis has a marked resemblance to *cancer*. Examination of an adequate specimen removed with punch-forceps may be the only certain means of diagnosis. Examination of the sputum, ordinary physical and X-ray examination of the chest, a careful record of the morning and evening temperature and pulse-rate, and inquiry into the family history, are all useful aids to diagnosis.

Treatment.—The disease starts in the lungs, and it is nearly always the pulmonary condition which is responsible for the patient's death. Treatment must therefore be primarily directed to the lungs. The usual sanatorium treatment includes an ample diet—*which should consist of soft, nourishing food*—*abundance of fresh* air, avoidance of tobacco and alcohol. Care must be taken to select a sanatorium suitable to the peculiarities of the patient. Complete silence may have to be observed for months. Creosote or guaiacol should be administered. Burney Yeo's inhaler is useful. Where dysphagia is present, powdered orthoform, blown into the larynx before a meal, will give relief. When pain is severe, alcohol may be injected into the superior laryngeal nerve. The application of caustics and curetting has been practically given up in favour of the actual cautery, which, however, is only to be used in selected cases. *It can be applied with the patient in the sitting position,* by the aid of indirect laryngoscopy. If the disease is confined to the epiglottis, the projecting portion of this structure can sometimes with advantage be removed.

SYPHILIS OF THE PHARYNX AND LARYNX

Primary syphilis is occasionally met with in the pharynx. The most usual site is the tonsil, *which becomes red, swollen, much in-*durated and eroded, and the submaxillary glands enlarge. Pain may be severe in character or may be absent. **Secondary** syphilis *generally makes* its appearance in from six weeks to four months after the primary infection. Erythema occurs in its most typical

form, as two symmetrical, crescentic patches of dusky-red hue, presenting an abrupt margin, situated on the soft palate and anterior pillars of the fauces. The tonsils may present an opalescent appearance. The erythema occurs about the same time as the skin rash. General hypertrophy of all the lymphoid structures of the pharynx is sometimes observed. Mucous patches correspond in time of appearance with the papular cutaneous syphilide, but occasionally they are late in developing, being met with many years after the initial infection. They occur on the lips, buccal mucous membrane, soft palate and tonsils, naso-pharynx, and larynx. The patches are slightly elevated, bluish-white in colour, with milky surface and a narrow zone of surrounding inflammation. In neglected cases condylomata may occur. Superficial ulceration is a late secondary manifestation. Any of the above lesions may be accompanied by enlargement of the epitrochlear and suboccipital glands, loss of hair, and other general symptoms. If the diagnosis is in doubt, a specimen from the throat should be examined for the *Spironema pallidum*, or the Wassermann test carried out. The symptoms include discomfort in the throat, or actual dysphagia, and hoarseness if the larynx is involved. Many years generally elapse between the primary infection and the onset of tertiary manifestations—three to fifteen years, or more. A gumma may be circumscribed or diffuse. The former is a semi-elastic, red swelling, presenting, when about to break down, a yellow centre. A nodular variety closely resembling lupus is described. When a gumma involves the soft palate, ulceration generally first appears on the posterior surface, and the red and swollen palate is liable to be mistaken for an acute inflammatory condition. The typical gummatous ulcer has a deep crater-like cavity, the base of which is covered with a dirty-yellow or grey slough. The tissues around the ulcer are red and infiltrated. Perforation of the hard or soft palate or faucial pillars may result from destruction of tissue, and later on scarring and adhesions sometimes give rise to great deformity. Stenosis or actual occlusion of the pharyngeal isthmus sometimes occurs from adhesion of the remains of the soft palate to the posterior pharyngeal wall. When the larynx is attacked, perichondritis may arise from deep extension, or the presence of an infiltration beneath the perichondrium. In either case necrosis of the underlying cartilage is a likely sequence. Dyspnœa may occur, from œdema, hypertrophic outgrowths, cicatricial stenosis, impaction of necrosed cartilage, fixation of the crico-arytenoid joints, or paralysis of the vocal cords It is well to remember that dyspnœa is sometimes caused by narrowing of the trachea. The absence of pain is characteristic of syphilis, but occasionally it is severe and requires insufflations of orthoform.

In hereditary syphilis the lesions are very similar to those of the

skin. The movable cartilaginous portion passes inwards with a slight inclination upwards and backwards. The bony meatus passes inwards and slightly downwards and forwards. Upward and backward traction on the auricle brings the two portions into line. In the adult the meatus is 1–1½ in. long. In infants there is no bony meatus, and the upper and lower walls are in contact, forming a slit.

The middle ear.— three ossicles, malleus, incus, and stape between the tympanic membrane anc d by mucous

is divided into several compartments by the ossicles, ligaments, and various folds of mucous membrane. The upper portion is called the *attic.* The *tympanum has six walls, of which the inner wall is surgically the most* important. It presents the following structures from above downwards, viz. (1) the Fallopian aqueduct, containing the facial nerve, (2) the fenestra *ovalis and the foot-plate of the stapes, (3) the promontory, (4) the fenestra* rotunda and the membrane closing it. This wall is closely related to the labyrinth. The outer wall is formed mainly by the tympanic membrane. The roof is composed of a thin plate of bone which is sometimes deficient; The floor is in proximity ie orifice of the Eustachian triangular opening of the g; it passes inwards, forwards, and downwards In the infant it is wide and short. The *antrum* is situated behind the tympanum, and the *aditus* connects these two cavities. It lies deep in the upper portion of the mastoid process, and is covered by a part of the squamous bone. Its roof, which is composed of the same plate of bone as the roof of the tympanum, is thin, and lies in relation to the middle fossa. Its posterior wall is related to the posterior fossa and groove for the lateral sinus, while the inner wall presents the eminence of passes downwards in rela-

behind and below the meatus and tympanum; it varies much in density. *Three types are met with, the pneumatic, the spongy,* and the sclerotic. Air-cells frequently extend beyond the mastoid into the squamous and petrous elements.

METHODS OF EXAMINATION

The occupation, habits, and family history of the patient may have an important bearing on the diagnosis and course of the disease A careful inquiry should be made regarding *the onset of the attack,* and of rigors, severe the case. For *ecting forehead* ost convenient.

A bright source of light is essential, and an aural speculum with an elliptical is the most useful. In adults, before the speculum is introduced

in colour. The short process of the malleus forms a tiny white knob, projecting downwards and backwards from which is the handle of the malleus. It terminates at the centre of the membrane in the umbo. From this point a cone of light projects downwards and forwards (Fig. 711). From the short process the anterior and posterior folds pass forwards and backwards respectively. Above the short process lies Shrapnell's membrane. The presence of bulging or retraction of the membrane should be noted, also

Examination of the Eustachian tubes.—In *Valsalva's method* the patient pinches the nostrils and blows out the cheeks. In the presence of a perforation, air may be heard to escape from the ear.

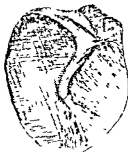


Fig. 711.—Normal tympanic membrane of right ear.

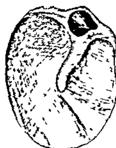


Fig. 712. — Retracted membrane, with perforation of Shrapnell's membrane.

In *Politzer's method* a large rubber bag with a hard nozzle is used. The patient is instructed to take a mouthful of water, and the rubber nozzle is inserted into the nostril corresponding to the ear which is to be inflated. The nose is compressed over the nozzle. While the patient swallows, or inflates his cheeks, the bag is suddenly compressed, and through an auscultation tube air is heard to enter the tympanum if the Eustachian tube is free

Inflation with the catheter.—This instrument consists of a malleable silver tube curved at one end, and expanded at the other so as to receive the nozzle of the inflating apparatus, which is somewhat similar to Politzer's bag. Three sizes of catheter should be at hand. The nose and naso-pharynx are first of all cocainized and the catheter passed along the inferior meatus until it touches the posterior wall of the naso-pharynx. If the right tube is to be catheterized the instrument is rotated until the ring points to the right and slightly upwards, and is then slowly withdrawn. The beak is felt to pass over the Eustachian cushion and into the orifice of the tube. For catheterization of the left tube the process is reversed Several modifications of this method are in use The surgeon now inserts the nozzle of the inflating apparatus into the expanded end of the catheter, and places one end of the auscultation tube in his own ear and the other in that of the patient. The character of the sound on inflation varies with the condition of the Eustachian tube and tympanum.

Hearing tests.—The normal range varies from 18,000 to 40,000 double

skin. The movable cartilaginous portion passes inwards with a slight inclination upwards and backwards. The bony meatus passes inwards and slightly downwards and forwards. Upward and backward traction on the auricle brings the two portions into line. In the adult the meatus is 1–1½ in. long. In infants there is no bony meatus, and the upper and lower walls are in contact, forming a slit.

The middle ear.—The *tympanum* proper contains the three ossicles, malleus, incus, and stapes, which act as a connecting link between the tympanic membrane and the labyrinth The cavity is lined by mucous

folds of mucous membrane. The upper portion is called the *attic*. The tympanum has six walls, of which the inner wall is surgically the most important. It presents the following structures from above downwards, viz. (1) the Fallopian aqueduct, containing the facial nerve, (2) the fenestra ovalis and the foot-plate of the stapes, (3) the promontory, (4) the fenestra rotunda and the membrane closing it. This wall is closely related to the labyrinth. The outer wall is formed mainly by the tympanic membrane. The roof is composed

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METHODS OF EXAMINATION

The occupation, habits, and family history of the patient may have an important bearing on the diagnosis and course of the disease A careful inquiry should be made regarding the onset of the attack, and an attempt made to discover an exciting cause. A history of rigors, severe headache, giddiness, vomiting, may alter the whole aspect of the case. For inspection of the meatus and tympanic membrane a reflecting forehead mirror with a focal distance of about 12 in will be found most convenient. A bright source of light is essential, and an aural speculum with an elliptical orifice is the most useful. In adults, before the speculum is introduced the auricle is pulled upwards and backwards, and in infants downwards and backwards, but in children a speculum can sometimes be dispensed with. The meatus is carefully inspected. Redness and bulging of its posterior wall is an important sign. The normal tympanic membrane is bluish or whitish

in colour. The short process of the malleus forms a tiny white knob, projecting downwards and backwards from which is the handle of the malleus. It terminates at the centre of the membrane in the umbo. From this point a cone of light projects downwards and forwards (Fig. 711). From the short process the anterior and posterior folds pass forwards and backwards respectively. Above the short process lies Shrapnell's membrane. The presence of bulging or retraction of the membrane should be noted, also the site and size of perforations and the character of any discharge. (Fig. 712.) Siegle's speculum is used in order to obtain a magnified view, to investigate the movements of the membrane, and to suck discharge through a perforation.

Examination of the Eustachian tubes.—In *Valsalva's method* the patient pinches the nostrils and blows out the cheeks. In the presence of a perforation, air may be heard to escape from the ear.

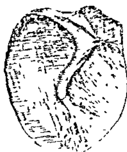


Fig 711.—Normal tympanic membrane of right ear.

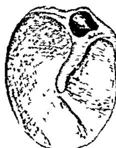


Fig. 712. — Retracted membrane, with perforation of Shrapnell's membrane.

In *Politzer's method* a large rubber bag with a hard nozzle is used. The patient is instructed to take a mouthful of water, and the rubber nozzle is inserted into the nostril corresponding to the ear which is to be inflated. The nose is compressed over the nozzle. While the patient swallows, or inflates his cheeks, the bag is suddenly compressed, and through an auscultation tube air is heard to enter the tympanum if the Eustachian tube is free

Inflation with the catheter.—This instrument consists of a malleable silver tube curved at one end, and expanded at the other so as to receive the nozzle of the inflating apparatus, which is somewhat similar to Politzer's bag. Three sizes of catheter should be at hand. The nose and naso-pharynx are first of all cocainized and the catheter passed along the inferior meatus until it touches the posterior wall of the naso-pharynx. If the right tube is to be catheterized the instrument is rotated until the ring points to the right and slightly upwards, and is then slowly withdrawn. The beak is felt to pass over the Eustachian cushion and into the orifice of the tube. For catheterization of the left tube the process is reversed Several modifications of this method are in use The surgeon now inserts the nozzle of the inflating apparatus into the expanded end of the catheter, and places one end of the auscultation tube in his own ear and the other in that of the patient. The character of the sound on inflation varies with the condition of the Eustachian tube and tympanum.

Hearing tests.—The normal range varies from 18,000 to 40,000 double

vibrations per second. An ordinary watch should be audible at a distance of 40–50 in., and Politzer's acoumeter at a distance of about 50 ft. In testing the hearing the other ear should be closed with the tip of the moistened finger. If a tuning-fork of 128 d.v. is held with its base in contact with the mastoid process until the sound dies away, and is then placed so that its vibrating prongs are close to the meatus, it will again be heard and will continue to sound for a period equal to that in *which it was in contact with the mastoid*. *In* other words, normally air-conduction is about twice as long as bone-conduction (*Rinne's test*). Tuning-forks are suitable for testing the lower tones; for high tones, Galton's whistle or the monochord must be employed.

Various tests are used for distinguishing middle- from internal-ear deafness. In diseases of the middle ear there is impairment of hearing for the lower tones, whereas in labyrinthine disease the high tones are curtailed. In middle-ear deafness the air- and bone-conduction ratio is altered, and in pronounced cases reversed, so that the fork is actually heard longer by bone- than by air-conduction. In internal-ear *deafness*, bone-conduction is reduced so that the fork is heard better when placed opposite the meatus In middle-ear deafness a fork placed in contact with the mastoid is heard better by the patient than by the examiner (*Schwabach's test*). The reverse is the case in internal-ear deafness. A tuning-fork placed in *the middle line of the head is referred in unilateral middle-ear deafness to* the affected ear, in unilateral labyrinthine deafness to the sound ear (*Weber's test*). In *Gelle's test* a tuning-fork is placed on the mastoid and the air in

[illegible]

occurs.

INJURIES AND AFFECTIONS OF THE PINNA

Perichondritis or *erysipelas may follow an injury or operation* involving the meatus. Blows on the auricle sometimes give rise to effusion of blood (*hæmatoma auris*) beneath the perichondrium, followed by permanent thickening; or necrosis of cartilage, with a shrunken and crumpled auricle, *may result. When blood or pus* accumulates beneath the perichondrium an incision may be called for. *Herpes* of the auricle is of special interest as it sometimes leads to an erroneous diagnosis. The skin of the pinna and meatus may be considerably swollen, and pain *is sometimes complained of. The* 7th and 8th nerves may be involved, with resulting facial paralysis and deafness, and symptoms of vestibular irritation may occur. The condition has been mistaken for mastoiditis.

EXCESS OF CERUMEN

Cerumen is only produced in the outer portion of the meatus. A plug is formed, and as fresh material is secreted it is pushed inwards; thus the whole meatus may become filled. The epithelium lining the canal is frequently exfoliated and mixes with the wax, forming a very hard substance, or it may form a layer outside a

central ceruminous core. Deafness, tinnitus, and occasionally giddiness result.

Treatment consists in removal of the plug, preferably after softening night and morning with a solution of sodium bicarbonate, gr. 20 to water 1 oz. In some cases it is possible to remove the whole or a portion of the mass with a small hook or spoon. With such an instrument a channel may be made between the plug of wax and the meatal wall, and fluid can reach the fundus of the meatus through this passage. The best fluid for syringing is a warm solution of bicarbonate of soda. The ear should be pulled upwards and backwards, the nozzle inserted so that it is in contact with the upper posterior wall, and the fluid injected under moderate pressure. A suitable tray receives the washings as they run from the ear. After removal of the cerumen the meatus is dried. Sterile instruments and lotions should be used in every case, as a perforation may be present.

FURUNCULOSIS, DIFFUSE INFLAMMATION OF THE MEATUS, ETC.

Boils develop only in the cartilaginous portion of the meatus. Fullness and soreness are complained of, soon followed by definite pain which, as the swelling increases, may become unbearable. As the meatus becomes occluded, deafness develops. There may be no apparent cause, but sometimes boils follow slight trauma such as an abrasion from scratching with the finger-nail. Eczema and purulent middle-ear discharge favour their formation. Before any swelling appears, points of tenderness may be demonstrated by the use of a probe. The tissues in the neighbourhood, especially over the mastoid, may become œdematous, and the adjacent glands swollen and tender. The main points of differential diagnosis between this condition and acute mastoiditis are that the ear is displaced forwards instead of downwards and forwards, that manipulation of the auricle and pressure on the tragus cause pain, and that pain is present on movement of the jaw.

Treatment should begin with a brisk purge; the diet may have to be regulated, and suitable tonics prescribed. In the early stages the local application of alcohol 96 per cent. may be tried, perhaps with the addition of 2-per-cent. carbolic acid and 5-per-cent. cocaine, or gauze soaked in 10-per-cent. ichthyol solution may be inserted in the meatus and frequently changed. For the pain, aspirin should be administered internally, and dry heat applied to the ear. When the pain is very severe and the condition is localized, or if a definite abscess is present, the swelling should be incised. Occasionally an incision behind the ear is necessary, but, when possible,

such incision should be avoided. Autogenous vaccines are useful, and may prevent recurrence.

Diffuse inflammation of the meatus may affect the whole length of the canal, and may result from injury by foreign bodies, unskilled attempts to remove them, middle-ear suppuration, syphilis, or herpes, but the most common variety is eczematous.

Lupus, syphilis, rodent ulcer, and *epithelioma* sometimes attack the auricle. Epithelioma tends to spread inwards by way of the meatus, the bone eventually becoming involved. If the disease is seen early and an extensive operation carried out on the ear and glands, a lasting cure may be obtained.

EXOSTOSES

These tumours of the external meatus occur most frequently in men. The etiology is obscure, but frequently contact with sea-water, as in swimming and diving, has been cited as a cause. A rounded tumour, sessile or pedunculated, is attached to the meatal wall. Sometimes the exostoses are multiple. The probe will demonstrate the swelling to be of stony hardness. Operation is indicated only when deafness results from one or both canals being completely occluded, or when there is suppurative otitis media. If pedunculated, the tumour can easily be detached by the tap of a chisel. Sessile and multiple tumours must be dealt with through an incision behind the ear. When there is associated middle-ear suppuration a mastoid operation will be necessary.

FOREIGN BODIES

A great variety of foreign bodies has been met with, including beads, buttons, seeds and kernels, peas, insects. The patients are generally children. If the foreign body is rough, angular, or impacted, inflammation accompanied by great pain may result. Small foreign bodies may not give rise to symptoms. If the meatus is occluded, deafness will ensue.

Treatment.—The size, shape, and character of the intruder must first be ascertained. Removal will be difficult in the case of a large foreign body which has been forced past the isthmus, it may be by unskilful attempts at extraction. Occasionally a foreign body has been driven into the tympanum, and a fatal result may then follow. The large majority of foreign bodies can be removed by syringing. The stream of water should be directed into any gap which exists between the body and the meatal wall. If no gap is present it may be possible to create one by pulling the auricle upwards and backwards. Some bodies, such as peas, swell up as the result of moisture, and a hook may be required for

their removal. In dealing with rough bodies which have caused damage to the meatal wall, or become impacted, the hook is introduced through any existing chink. During introduction the terminal bend lies flat against the meatal wall; when it has passed beyond the body the hook is rotated and traction applied. In children an anæsthetic is necessary. As a last resource it may rarely be necessary to open the external auditory meatus posteriorly and to detach the cartilaginous from the bony portion of the wall in order to gain access to the foreign body.

INJURIES TO THE EAR

In fractures of the base of the skull the labyrinth, middle ear, and meatus may be involved, and in such cases rupture of the tympanic membrane is common. Fracture of the anterior meatal wall sometimes results from blows on the mandible. The tympanic membrane is liable to be damaged by clumsy attempts at the extraction of foreign bodies. Accidental wounds with sharp instruments, violent explosions, or a blow on the ear with the open hand, account for some cases A loud sound may be heard by the patient at the moment of rupture, followed by earache, deafness, tinnitus, and giddiness. When injury to the labyrinth accompanies a fractured base, the deafness is liable to be complete and permanent, vertigo pronounced, and there may be an escape of cerebro-spinal fluid. In such cases meningitis or sinus phlebitis may follow, sometimes after a quiescent interval.

Treatment consists in protecting the meatus with a pledget of cotton-wool. The ear should on no account be syringed, and the patient should avoid violent blowing of the nose, as infection is liable to be forced along the Eustachian tube. If suppuration occurs, it must be treated in the manner presently to be described (p. 326).

PURULENT INFLAMMATION OF THE MIDDLE EAR

Etiology.—Mainly owing to the existence of adenoids, this disease is more common in children. Overcrowding, insufficient nourishment, and ill-health from whatever causes are predisposing factors. The more important exciting causes are—(1) a common cold; (2) the exanthemata, especially scarlet fever, measles, and diphtheria; (3) influenza, pneumonia, whooping-cough; (4) extension of infection along the Eustachian tube following operations on the nose and naso-pharynx, or the plugging of these cavities for the arrest of hæmorrhage, or the passage of a septic Eustachian catheter; (5) trauma; (6) the use of a nasal douche, swimming under water, diving; (7) tuberculosis, syphilis, and malignant disease.

Pathology.—There is great engorgement of the vessels situated in the muco-periosteal lining of the tympanum, followed by migration of leucocytes and transudation of serum. Within a period varying from a few hours to some days the secretion becomes purulent and the swollen tympanic membrane is pushed outwards so that it bulges and finally ruptures. The discharge may last for only a few hours, or, once established, may persist through life. The duration of the suppurative process depends on many factors, among which may be mentioned (1) the nature of the original infection; (2) the constitution of the patient; (3) the presence of adenoids, nasal-sinus suppuration, etc.; (4) whether or not suitable treatment has been adopted; (5) the size and situation of the perforation—marginal perforations are liable to be associated with cholesteatoma and caries; (6) the type of mastoid process, the size of the antrum and aditus. As the condition becomes chronic, granulations and polypi, generally pointing to caries, spring up. Necrosis is rare, except in tuberculous cases. Cholesteatomatous formations may fill the middle ear and antrum, and by erosion invade the labyrinth, the middle or posterior fossæ. The most common organisms in the acute form are the streptococcus and pneumococcus. Before perforation of the drum-head they are generally present in pure culture. In chronic infections nearly every type of organism may be present.

Symptoms.—A sensation of fullness in the ear may precede the pain, which is usually intense, and is described as piercing, boring, or throbbing, as a rule worse at night, and perhaps making sleep impossible. It tends to radiate over the side of the head. When the membrane ruptures, relief is generally immediate. Persistence of pain and temperature in the presence of a free discharge points to some complication such as mastoiditis, labyrinthitis, sinus thrombosis or meningitis. A high temperature (up to 105° F.), with a rapid pulse, is sometimes present in children, even when there is no complication. Deafness is generally pronounced. An unusual phenomenon is paralysis of the 6th nerve, and the facial nerve is occasionally involved. Tinnitus and giddiness are sometimes present. In chronic middle-ear suppuration the patients frequently complain of nothing beyond deafness and a discharging ear. The discharge is generally foul; if very evil-smelling, it may indicate cholesteatoma or caries. Pain occurring in a case of this sort is of serious import. Marked giddiness, rigors, vomiting, and wasting point to the disease having passed beyond the confines of the middle ear. If, in acute otitis media, the inflammation subsides without rupture, or if the rupture quickly heals, an intact membrane with normal hearing will generally be left. When suppuration continues over a long period the patient is usually left with a perforation, adhesions frequently fix the ossicles, or the malleus

and incus may be partially or completely destroyed. The amount of hearing left will depend on the state of the mucous membrane over the inner tympanic wall, on the condition of the ossicles, and more especially on the mobility of the stapes. If the patient be examined early in the acute stage the upper part of the membrane shows injection; this gradually spreads downwards, and in time the whole membrane is involved. Later, owing to the accumulation of fluid in the tympanum, the membrane bulges. The posterior superior meatal wall generally shares in the congestion and becomes indistinguishable from the membrane. Eventually necrosis occurs at one particular spot and a perforation results, allowing the secretion to escape. The perforation is easily recognized unless it is very small or situated near the upper or lower attachment of the membrane. (Fig. 713.) Sometimes an invisible perforation can be inferred from the reappearance of a bead of secretion after it has been wiped away, or pus may be sucked through the tiny opening by using a Siegle's speculum. Again, on inflation, a hissing sound may be heard as air passes through the perforation. Occasionally a small perforation appears at the centre of a nipple-shaped projection. The discharge is at first thin and straw-coloured, later it becomes muco-purulent or purulent. It is sometimes hæmorrhagic, especially in influenzal cases. In chronic cases the perforation is often large, and nearly the whole membrane may have disappeared. The margins of the opening are thickened, and sometimes present small granulations. A polypus may project through the perforation and later on fill the whole meatus; its origin is nearly always in some portion of the middle ear. Perforations of Shrapnell's membrane are often associated with caries of the attic and ossicles, and if the perforation is situated above and posteriorly, it indicates disease of the antrum and aditus. In cases where a cholesteatoma is present, epithelial scales may be discovered in the discharge or the meatus may be filled with foul-smelling, putty-like material. The same material is sometimes seen exuding from a perforation which is nearly always situated near the periphery. The discharge in chronic cases is often scanty. Occasionally it contains particles of bone.

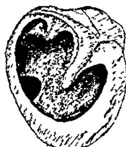
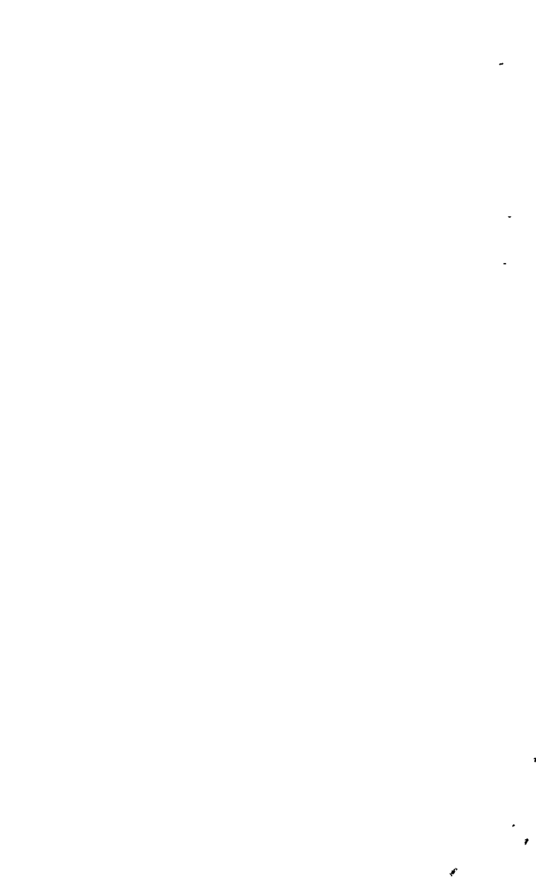


Fig. 713.—Large perforation of tympanic membrane, showing fenestra rotunda below and behind.

Course and consequences.—Rupture of the membrane may occur in from a few hours to a few days, but may be delayed for more than a week. Resolution sometimes takes place without rupture. In most cases the discharge gradually diminishes, the membrane

Pathology.—There is great engorgement of the vessels situated in the muco-periosteal lining of the tympanum, followed by migration of leucocytes and transudation of serum. Within a period varying from a few hours to some days the secretion becomes purulent and the swollen tympanic membrane is pushed outwards so that it bulges and finally ruptures. The discharge may last for only a few hours, or, once established, may persist through life. The duration of the suppurative process depends on many factors, among which may be mentioned (1) the nature of the original infection; (2) the constitution of the patient; (3) the presence of adenoids, nasal-sinus suppuration, etc.; (4) whether or not suitable treatment has been adopted; (5) the size and situation of the perforation—marginal perforations are liable to be associated with cholesteatoma and caries; (6) the type of mastoid process, the size of the antrum and aditus. As the condition becomes chronic, granulations and polypi, generally pointing to caries, spring up. Necrosis is rare, except in tuberculous cases. Cholesteatomatous formations may fill the middle ear and antrum, and by erosion invade the labyrinth, the middle or posterior fossæ. The most common organisms in the acute form are the streptococcus and pneumococcus. Before perforation of the drum-head they are generally present in pure culture. In chronic infections nearly every type of organism may be present.

Symptoms.—A sensation of fullness in the ear may precede the pain, which is usually intense, and is described as piercing, boring, or throbbing, as a rule worse at night, and perhaps making sleep impossible. It tends to radiate over the side of the head. When the membrane ruptures, relief is generally immediate. Persistence of pain and temperature in the presence of a free discharge points to some complication such as mastoiditis, labyrinthitis, sinus thrombosis or meningitis. A high temperature (up to 105° F.), with a rapid pulse, is sometimes present in children, even when there is no complication. Deafness is generally pronounced. An unusual phenomenon is paralysis of the 6th nerve, and the facial nerve is occasionally involved. Tinnitus and giddiness are sometimes present. In chronic middle-ear suppuration the patients frequently complain of nothing beyond deafness and a discharging ear. The discharge is generally foul; if very evil-smelling, it may indicate cholesteatoma or caries. Pain occurring in a case of this sort is of serious import. Marked giddiness, rigors, vomiting, and wasting point to the disease having passed beyond the confines of the middle ear. If, in acute otitis media, the inflammation subsides without rupture, or if the rupture quickly heals, an intact membrane with normal hearing will generally be left. When suppuration continues over a long period the patient is usually left with a perforation, adhesions frequently fix the ossicles, or the malleus



loses its congested appearance, and the perforation heals. During the acute stage complications may arise, including extension of the suppuration to the mastoid antrum and cells, or to the labyrinth; facial paralysis, involvement of the meninges and brain, or of the *lateral sinus*. *All* these conditions may also develop in chronic cases. Complications are apt to occur in debilitated subjects, after influenza and the specific fevers, when there is nasal or postnasal disease, and when the organism responsible for the infection is the streptococcus.

Treatment.—In acute suppurative otitis the patient should be confined to bed and kept on a light diet, and a few grains of calomel administered, followed if necessary by a saline purgative. Tobacco and alcohol should be avoided. The pain is best combated by local applications of heat, and nothing is better than a hot-water bottle covered with flannel. The whole head may be wrapped up in cotton-wool, or a fomentation applied over the ear. A few drops of a 5-per-cent. solution of carbolic acid in glycerine may be run into the ear three or four times daily, or almond oil containing 2 gr. of cocaine and 3 gr. of carbolic acid to the drachm may be employed. Aspirin, pyramidon, or phenacetin will generally help to relieve the pain, but morphia hypodermically may be necessary.

If the membrane is definitely bulging and there are associated pain, temperature, and rapid pulse, and more especially if the posterior meatal wall is swollen, the drum-head should be incised. Tenderness over the mastoid is a still more definite indication for paracentesis (p. 330), which, if it is carried out at once, may sometimes *avert a mastoid operation*.

When the patient has entirely recovered from the acute suppuration, any predisposing condition, such as enlarged tonsils and adenoids, should be dealt with. Frequently recovery is complete; hearing returns to normal, and no evidence of a previous perforation is left in the membrane. The treatment of aural discharge when it *becomes chronic depends* very greatly on the clinical picture presented on examination. When the perforation is large and the discharge scanty, occasional cleansing may be all that is required. In such cases the application of caustics, etc., to the tympanum should be avoided, as they may rob the patient of what hearing is left. Occasionally, discharge is kept up by reinfection through the Eustachian tube. Polypi and granulations interfere with examination, drainage, and treatment, and they must be removed. If small, they may be touched with silver nitrate fused on a probe, or trichloracetic acid, after preliminary cocainizing; if large, they should be removed with the snare. Recurring polypi, cholesteatoma, and caries *usually indicate* the necessity for a mastoid operation. Chronic

discharge from the ear is best treated by syringing with an antiseptic lotion such as boric-acid, or a weak solution of iodine. Syringing should be frequent if the discharge is copious. It is a good plan to fill the meatus with hydrogen peroxide (10 vols.) five minutes before syringing. After syringing, the meatus is dried and filled with rectified spirit 96 per cent., if it can be tolerated; this should be left in the canal for 5–15 minutes. Finally, it is often a good plan to fill the meatus with boric-acid powder. It is better to carry out treatment of this sort thoroughly once a day than to syringe the ear in a perfunctory manner several times a day. Local application of astringents, such as 10-per-cent. argyrol, may prove useful. If ordinary methods fail to cure the discharge, ionization should be given a trial. When the ear becomes dry and the perforation heals, hearing can sometimes be improved by inflation. When the perforation is opposite the fenestra ovalis, an artificial drum, consisting of a small pellet of cotton-wool soaked in sterile oil, will occasionally benefit the hearing.

SUPPURATIVE LABYRINTHITIS

Before describing some of the features of this disease, it is necessary to make a few remarks on the **vestibular tests.**

Nystagmus may be induced by movements of fluid in the semicircular canals. Ewald discovered that (1) excitation of a canal caused nystagmus in a plane parallel to the plane of the canal; (2) the direction of the endolymph movement determines the direction of the nystagmus. In vestibular nystagmus there is a quick movement of the eyes in one direction and a slow return in the opposite direction. The nystagmus is named according to the direction of the quick movement.

Caloric reaction.—If one injects water well below the body tempera- [illegible]

[illegible] Thus, if the right ear is syringed with cold water, the quick component is towards the left, and the nystagmus is increased on looking to the left.

Rotation experiment.—If a normal person is rotated with head erect from left to right (clockwise), and after ten complete turns the rotation is stopped, nystagmus will take place and the quick movement will be to the left. Reverse the direction of rotation, and the nystagmus is reversed.

Pointing tests.—A normal person, having located an object (e.g. the examiner's forefinger) with his own forefinger, can, with eyes closed, lower his finger for some distance, then raise it and again touch the examiner's finger. When the vestibular apparatus is disturbed, either by disease or by artificial means, pointing becomes inaccurate; the error occurs in the direction of the slow component of the nystagmus.

Etiology and symptoms.—Inflammatory changes in the labyrinth take place as the result of acute, or more frequently of chronic, middle-ear suppuration. The condition may be acute or chronic, circumscribed or diffuse, serous or purulent. The localized form is usually the *result of caries over the external* semicircular canal, and is generally associated with cholesteatoma. It may remain localized or become diffuse. Labyrinthitis associated with acute suppurative otitis media results, as a rule, from spread of infection through the inner wall of the middle ear. The fenestra ovalis is the most frequent port of entry. The *symptoms of acute generalized* labyrinthitis include pain, vertigo, ataxia, nausea and vomiting, loss of hearing, spontaneous rotato-lateral nystagmus with the quick phase towards the sound ear. The nystagmus increases when the patient looks towards the sound side, and tends to diminish or disappear when he looks towards the diseased side. The patient also tends to fall towards the diseased ear, the direction of his fall being dependent on the position of the head. Frequently he is too giddy to *stand. When in bed he prefers to lie on the* sound ear. *If the* labyrinth is destroyed, irrigation of the affected ear will have no effect on the nystagmus.

Treatment of suppurative labyrinthitis. — Amongst otologists there is a great diversity of opinion both as to the *advisability of operation and as to the character and extent of the* operation, should operative interference be deemed necessary.

Under certain conditions an operation on the internal ear would seem to be definitely indicated. They include (1) suppurative labyrinthitis with symptoms indicating early meningitis; (2) the escape of pus from the fenestra ovalis or from a labyrinthine fistula at a mastoid operation; (3) necrosis of the labyrinthine capsule associated with suppuration; (4) symptoms of diffuse labyrinthitis following a *radical mastoid operation. In suppurative labyrinthitis supervening* on middle-ear suppuration, but uncomplicated by any intracranial lesion, the patient should be kept absolutely at rest in bed. All unnecessary movement of the head must be avoided, and the usual local and general treatment for acute suppurative otitis carried out. *If such a case should recover,* various opinions are held as to whether the resulting condition of latent labyrinthitis should or should not be submitted to a radical labyrinth operation. When, during the performance of a radical mastoid operation, a *fistula of the* external semicircular canal is discovered, or that prominence is found to be covered with granulations, it is best to leave the condition alone. Numerous operations on the labyrinth have been described. The surgeon's aim should be to establish drainage of *the diseased* internal-ear spaces. This can generally best be accom-

plished in panlabyrinthitis by removing the bridge of bone between the oval and round windows and uncovering a portion of the first turn of the cochlea. A counter-opening is made behind the facial nerve by removing the outer wall of the external semicircular canal just behind its ampulla, and the outer wall of the ampulla itself, and opening the adjoining vestibule. In some cases the canal of the cochlea must be opened up and the internal meatus exposed. In this way translabyrinthine drainage of the meninges may be established. Some operators advocate the opening of all the semicircular canals and removal of the solid angle of bone between them; or, again, the cerebellar dura having been exposed internally to the lateral sinus, the whole portion of the petrous bone which lodges the canals is removed from behind forwards and the vestibule entered posteriorly.

For further information on this subject, and for an account of the non-suppurative diseases of the labyrinth, the reader is referred to the special textbooks cited in the Bibliography (pp. 336-37).

ACUTE INFLAMMATION OF THE MASTOID PROCESS

This disease is secondary to a similar condition affecting the tympanum. Probably in all cases of middle-ear suppuration the mastoid antrum and cells are involved. Owing to insufficient drainage, to virulence of infection, or to poor resistance on the part of the patient, mastoiditis may develop. The mastoid is more likely to be seriously involved in those cases which are associated with the specific fevers or influenza. In rare instances the tympanic disease clears up while the suppuration in the mastoid continues. Such cases may present a tympanic membrane which is normal in appearance. The process is at first confined to the mucous membrane. Subsequently the bone is involved, and not uncommonly partial absorption of the mastoid cortex takes place, with the formation of a fistula and the accumulation of pus under the periosteum. A subperiosteal abscess, however, frequently arises without the formation of a fistula. In infants pus may find its way to the surface through the petro-squamous suture. When a subperiosteal abscess forms there are swelling and tenderness over the mastoid, and the auricle is displaced forwards and downwards. A more unusual occurrence is for the pus to escape through the inner wall of a large apical cell and enter the digastric fossa. Then an abscess forms underneath the upper part of the sterno-mastoid (Bezold's abscess), and pressure on the swelling in the neck may cause escape of pus from the ear. Serious complications may result from the infection spreading upwards to the middle fossa, backwards to the posterior fossa and lateral sinus, inwards to the labyrinth. In a typical case of acute mastoiditis there will

be a history of recent acute otitis media, the aural displacement referred to will be present, perhaps associated with a definite post-auricular abscess, the posterior superior meatal wall and posterior superior quadrant will be bulging. Aural discharge may be absent, moderate, or copious. Tenderness is elicited on pressure over the mastoid antrum; sometimes it is greatest over the tip of the mastoid. Other things being equal, the tenderness and swelling will appear earlier in pneumatic mastoids. In examining for tenderness it is well to compare the diseased with the normal side. One or more of the above signs may be absent. Patients who are suffering from chronic middle-ear suppuration, more especially if cholesteatoma is present, may develop a condition clinically similar to acute mastoiditis, but more likely to be associated with serious complications.

Fig. 714.—Mastoid operation, showing exposure of the mastoid cortex.

Paracentesis.—The meatus should be previously cleansed by filling it with hydrogen peroxide and then syringing with biniodide-of-mercury [illegible] anæsthetic is necessary. With a special [illegible]

meatus. [illegible] This treatment [illegible] the occasional use of a Siegle's speculum. [illegible] rid the tympanum of its purulent contents. Occasionally paracentesis has to be repeated.

to come from the tympanic cavity alone, signs of commencing [illegible] involvement, meningitis or other intracranial complications, paralysis of the facial or abducent nerve.

The head is shaved for a considerable distance above and behind the ear, and the skin disinfected. The patient's head should lie on a sand-bag with the side to be operated on directed upwards and towards the surgeon. Sterile towels are so arranged as to leave the mastoid area exposed. The incision commences at the upper attachment of the auricle and passes downwards towards the tip of the mastoid The upper part of the incision is deepened as far as the temporal fascia, the lower part is carried down to the bone If a subperiosteal abscess is present, pus will escape. In every case a specimen should be taken for subsequent bacteriological examination. The periosteum is now elevated from the mastoid process, all bleeding-points are secured, and a self-retaining retractor is introduced and widely opened. Thus the mastoid cortex is exposed (Fig. 714), and the posterior margin of bony meatus, the suprameatal spine, the lower

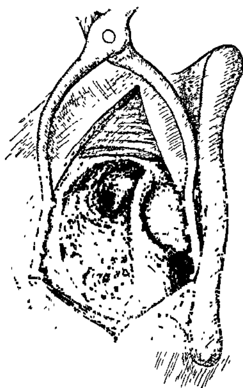


Fig. 715.—*Mastoid operation before removal of the posterior wall of the bony meatus.*

next proceeds to remove a portion of the mastoid cortex in such a manner that the deepest part of the bony excavation shall be formed by the antrum (Fig. 715). The bone is removed in layers with a gouge and hammer, the former being applied in an oblique manner, never at right angles to the bone. In acute cases the mastoid process is usually cellular, and many cells are entered and removed before the antrum is reached. Every suppurating

left behind the ear. In order to *facilitate healing*, some surgeons advocate the application of a large skin-graft to the mastoid cavity. The graft is applied before the closure of the posterior wound.

Sometimes it is possible to perform a modified radical operation. Such an operation should be adopted in cases with a fair amount of hearing where the disease is mainly confined *to the mastoid or to the attic*. The tympanic structures may be conserved, while the innermost portion of the posterior meatal wall is retained or very carefully removed. In all such conservative operations it is essential to avoid injury to the ossicles, more especially the incus, which is liable to be dislocated.

The **after-treatment** *varies much with the character of the operation* performed and whether or not skin-grafting has been carried out. It is [illegible] application of chemical caustics. The cavity should eventually be lined with epithelium.

ACUTE NON-PURULENT INFLAMMATION OF THE MIDDLE EAR

The symptoms closely resemble those of the early stages of acute purulent otitis media. Resolution, however, occurs without perforation. Repeated attacks are common, especially in children suffering from adenoids, and each time they are likely to become longer in duration. If associated with influenza or the exanthemata, they are likely to be protracted. The condition may be associated *with the accumulation* of a sero-mucous secretion in the tympanum. On rare occasions the upper *level of the fluid is seen through the tympanic membrane*, and the aural picture may change by altering the position of the *patient's head. After inflation, bubbles sometimes appear* in the fluid. In such cases paracentesis may be indicated, followed by *inflation of the tube*, and aspiration with a Siegle's speculum.

CHRONIC MIDDLE-EAR CATARRH

This condition may follow attacks of acute otitis media, suppurative or non-suppurative, or the disease may be insidious from the onset. It often originates in an attack of influenza or one of the exanthemata. Its victims frequently suffer from chronic affections of the nose and naso-pharynx, such as adenoids, septal spurs, turbinal hypertrophies, nasal-sinus disease. General ill-health and heredity are predisposing factors.

Pathology.—At first there is a round-celled infiltration in the mucous membrane, followed later by fibrous tissue-formation. The Eustachian tube may be affected alone, but usually the disease spreads to the tympanic cavity. *Cicatricial bands may form and limit* the movements of the ossicles, or bind the tympanic membrane to the

inner wall of the middle ear. The footplate of the stapes is occasionally fixed in the fenestra ovalis. Sometimes atrophy takes place, with localized or general thinning of the membrane and hyperpatency of the Eustachian tube. Late in the disease the labyrinth is liable to become affected. Deafness is generally, in the first instance, unilateral, and it may pass unobserved by the patient until the previously healthy ear becomes involved. In the second ear the process frequently is much more rapid. The patient is usually deafer during a cold in the head, and after each cold a lower standard of hearing is reached In some cases, more especially those in which the footplate of the stapes is fixed, the patient hears better in a noise (paracousis Willisiana). Tinnitus is usually present. It is constant or intermittent, and may be likened to hissing, blowing, singing, buzzing, or throbbing. Children rarely complain of this symptom. Vertigo may amount to nothing more than a transitory dizziness, but in rare instances it is so severe as to resemble that of Menière's disease. Pain and a sensation of fullness in the head are occasionally troublesome. A negative Rinne's test is said to indicate ankylosis of the stapes.

Objective signs.—The membrane is usually retracted; the handle of the malleus, drawn inwards and backwards, appears foreshortened. The short process, the posterior fold and annulus tympanicus, are unduly prominent. The cone of light is broken up. The membrane may be thickened, opaque like frosted glass, atrophied, or present calcareous patches. Examination with Siegle's speculum may show increased mobility of the membrane as a whole or in parts, or the membrane and ossicles may exhibit little or no movement. Auscultation sounds vary greatly. A narrowed Eustachian tube will be associated with a high-pitched sound of diminished volume. A harsh blowing sound is characteristic of an abnormally patent tube.

Prognosis.—The deafness is usually progressive, but the disease sometimes becomes arrested, or deterioration is very gradual. Patients who suffer from increased deafness during a cold will probably improve by treatment, more especially if a causative nasal lesion can be discovered and remedied. If the deafness is due to temporary Eustachian obstruction and if improvement follows inflation, the prognosis is favourable. Unfavourable cases are those in which adhesions have bound down the membrane and ossicles, and where the footplate of the stapes is fixed.

Treatment.—Any general conditions likely to have a bearing on the disease must be dealt with. Adenoids, abnormalities of the nose, septic teeth and tonsils should receive attention. When possible the patient should live in a dry climate. Consumption of tobacco

and alcohol must be limited. If definite improvement follows inflation with the catheter or Politzer's bag, it should be practised two or three times a week at first, and then at longer intervals. When the membrane is thinned it may do harm, and it is useless when the Eustachian tube *is patent or the footplate of the stapes fixed.* When a definite stricture is present, passage of the Eustachian bougie is sometimes beneficial.

OTOSCLEROSIS

Otosclerosis is somewhat more common in women than in men, and it appears most frequently between the ages of 20 and 40, although cases have been described at 15 or earlier. The disease attacks the bony capsule of the labyrinth, and the usual site of origin is immediately above and in front of the fenestra ovalis. The bone in this neighbourhood is absorbed and replaced by new bone of a spongy character. At a later date this bone becomes dense. The bony changes spread to the footplate of the stapes, which eventually becomes fixed in the oval window. The pathology is obscure. Gray holds that the condition may be due to failure in the local blood supply—the patients are often anæmic. Tinnitus is generally present, and if severe it may be the most distressing feature of the disease. The deafness is of the middle-ear type, and a negative Rinne test develops *The tympanic membrane is normal, or a rosy* blush may be present over the promontory. The Eustachian tube is patent. Paracousis Willisiana is frequently present. Shock and loss of blood have an unfavourable influence on the disease, and the hearing is likely to deteriorate after the birth of each child.

Treatment *consists* in attention to the general health and combating anæmia. Many drugs have been tried, but probably none has any specific action.

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and Ear. 1910

in daily practice, are imperative before the practitioner attempts to pass the tube without help. Fatal accidents have occurred, and were

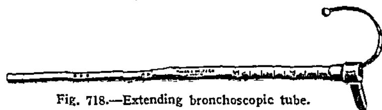


Fig. 718.—Extending bronchoscopic tube.

perhaps inevitable in the hands of pioneers: they will still occur if practitioners imagine that the proceeding is as easy as, or is comparable to, endoscopy of the rectum or vagina.

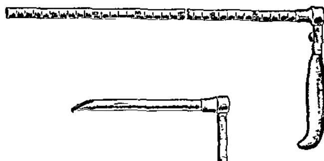


Fig. 719.—Œsophagoscopic tube (above) and laryngoscopic spatula tube (below).

The mechanical basis of the instrument is a rectangular handle containing an electric light which can be reflected down the examination tube and carefully focused (Fig. 717). To this various



Fig. 720.—Saliva pump.

tubes can be connected. For direct inspection of the larynx a tube spatula of 15 to 20 cm. (6–8 in.) in length is used. For the trachea and bronchi a tube is *employed which, with a telescope*

extension, can be elongated to 30 or 35 cm. (12–14 in.); and one capable of longer extension, or a series of tubes of increasing lengths, is required for œsophagoscopy.

LARYNGO-TRACHEO-BRONCHOSCOPY

Anatomical data.—The following points of surgical anatomy *may be recalled*:—

The distance from the upper molar teeth to the cricoid cartilage is about 6 in.

The trachea itself is 5 in. long, and extends from the cricoid cartilage to opposite the junction of the 4th and 5th dorsal vertebræ. *This point—the bifurcation of the trachea*—is behind the sternum, on a level with the second costal cartilage, and is 10 in. from the upper molar teeth.

The right bronchus is 3 in. long, and gives off its first branch (eparterial branch to the upper lobe) at a distance of 1 in. from the trachea. *(Cf. Fig. 721.)*

The left bronchus is 2 in. long before any subdivision takes place.

Anæsthesia.—In some adults, and always in *children*, a general anæsthetic is required. Chloroform, administered with a Junker's apparatus, is usually preferred. But in a large proportion of adults tracheo-bronchoscopy can be done under local anæsthesia. This is carried out as follows: A hypodermic injection of morphia ($\frac{1}{6}$ gr.) *with atropine sulphate ($\frac{1}{100}$ gr.) is given half an hour before* examination. The fauces, pharynx, and base of the tongue are sprayed with a 5-per-cent. solution of cocaine, and the epiglottis and endolarynx are painted with a 10-per-cent. solution, particular attention being given to the sensitive interarytenoid region. In about ten to twenty minutes the anæsthesia should be complete. If the endoscopic tube has to be carried into the bronchi it will be necessary to paint the *region of the bifurcation with the 10-per-cent. solution.*

When a general anæsthetic is administered, some cocaine will still [illegible] more lightly.
[illegible] be lying on [illegible] ad extended and turned to one side.

When only local anæsthesia is employed it is more convenient to have the *patient sitting on a low (10 in.) stool, with the body thrown* forwards and the face looking upwards and tilted to one side.

Method.—A tube is purified, warmed, and then passed through the corner of the mouth and directed to the middle line of the lower pharynx. Here the epiglottis is readily distinguished, and is *hooked forwards* with the beak of the instrument, thus bringing into view the glottis and the vocal cords, which can be watched in respiration

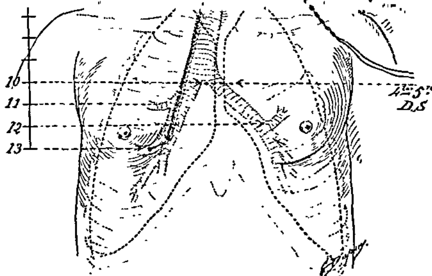


Fig. 721.—Direct bronchoscopy.

(*From the Author's "Diseases of the Nose and Throat"*)

Removal of a shawl pin impacted in a secondary bronchus (dorsal) of the right middle lobe On the right-hand side of this semi-diagrammatic drawing there is indicated the correspondence of the [illegible] to the 6th cervical spine, and of the bifurcation of the trachea to the interval

and phonation. During a quiet inspiration the tube is slipped between the cords, and readily glides down the windpipe until it reaches the bifurcation of the trachea. This region generally requires an application of cocaine, when the *telescopic extension of the tube can be* projected and tilted into one or other bronchus. (Fig. 721.)

ŒSOPHAGOSCOPY

Anatomical data.—The œsophagus begins behind the cricoid *cartilage (6th cervical vertebra) and terminates in the stomach* opposite the 10th or 11th dorsal vertebra.

The distance from the incisor teeth to the commencement of the œsophagus is 5–6 in. (15½–17 cm.). The length of the œsophagus itself is 9–10 in., made up of the following areas:—

1. Cervical portion, from the cricoid cartilage to the manubrium sterni, 1½–2 in. (4–6 cm.).
2. *Thoracic portion, from the top of the sternum to the* opening in the diaphragm, 7 in. (16–18 cm.).
3. Abdominal portion, 1 in. (2–3 cm.).

The distances from the incisor teeth are, therefore, as follows:—

To the ostium of the œsophagus ..	5–6 in. (15½–17 cm.).
To the top of the sternum	*6½–8* in.
To opposite the bifurcation of the trachea	10 in.
To where the left bronchus crosses it..	11 in.
To the cardiac end of the stomach ..	15–16 in.

These measurements should vary with the stature of the patient; those given here may be taken as average figures.

There are three normal constrictions at the three points of deviation *of the gullet—at the root of the neck, at the* arch of the aorta, and as it passes through the diaphragm.

Anæsthesia.—In children a general anæsthetic is necessary. [illegible] cases sufficient, and is obtained, [illegible] the pharynx, larynx, and par- [illegible] cricoid region with a 10–20 per cent. solution of cocaine. The preliminary injection of morphia is a great advantage, and in some sensitive patients, and nearly all operative cases, a general anæsthetic is inevitable.

Position.—As for tracheoscopy.

Instruments.—A series of tubes, or one which can be elongated from 8 to 20 in. (20–50 cm.), is required. The diameter of the tube should be 7 mm. for children, 9 mm. for females, and 9–13 mm. for male adults.

Method.—The tube is purified, warmed, and lubricated. The patient's head is extended and supported while it is inclined slightly

to the right. The extremity of the œsophagoscope is passed over the epiglottis and hitched behind the arytenoids. If this region has been well cocainized, the mouth of the œsophagus will open and allow the instrument to slip down the gullet. During the descent it is wise to define and follow the lumen, keeping clear of the posterior wall. The œsophagus is not a collapsed tube, as is generally taught, but is a fusiform sac closed at each end. It gradually diminishes in calibre all the way down.[1]

The ostium is a transverse slit, closed except for the passage of food or the eructation of gas or mucus.

No force should be employed in passing the œsophagoscope. When the field of vision is obscured in pathological cases by mucus and débris of arrested food, it must be dried by swabs and an aspiration pump. (Fig. 720.)

Contra-indications.—Direct laryngo-tracheo-bronchoscopy, if not an easy, is at any rate a comparatively safe procedure. Œsophagoscopy in clumsy, impatient, or untrained hands may be a very dangerous undertaking. [illegible] out beforehand, to avoi[illegible] lower pharynx, or push [illegible]. Large aneurysms, mediastinal tumours, cervical caries and abscess, and foreign bodies which have produced cellulitis or emphysema would render œsophagoscopy very dangerous. A stricture should never be forced. The œsophagus in disease becomes a very fragile tube, and no inconsiderable number of fatalities have resulted from unskilled manipulation

[1] G. McClemman, *Trans. Amer. Laryngol Assoc.*, 1911, p. 10.

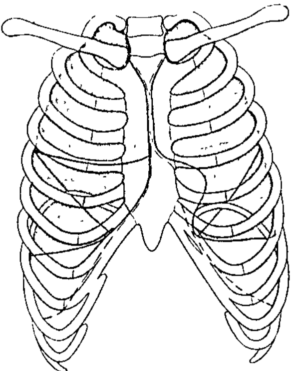


Fig 1.—Front view of thorax showing relationship to chest wall of lung (dark shading), fissures of lung (dark lines), pleura (light shading), and diaphragm (colour).

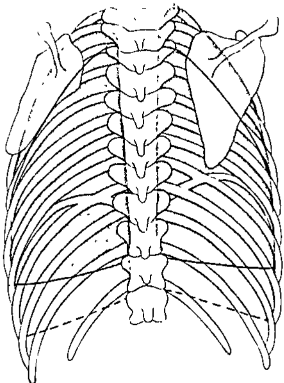


Fig 2—Back view of thorax, showing relationship to chest wall of lung (dark shading), fissures of lung (dark lines), pleura (light shading), and diaphragm (colour). On the left side the scapula is shown in the position assumed when the arm is elevated above the head Note the correspondence of the longitudinal fissure to the vertebral border of the scapula

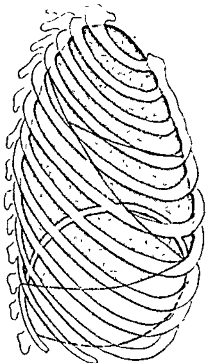


Fig 3—Side view of thorax, showing relationship to chest wall of lung (dark shading), fissures of lung (dark lines) pleura (light shading), and diaphragm (colour).

PLATE 116.

sternum to the 6th cartilage. The line follows this cartilage, crosses the 7th and the costo-chondral junction of the 8th rib, from which point it is identical with that described for the right side.

The pleural membranes of either side come into close approximation posteriorly behind the mediastinum, where the vertebro-mediastinal pleural sinus extends on the right side behind the œsophagus and in front of the vena azygos major and possibly even the aorta. On the left side also there is a slight mesial protrusion. In this region the two pleural cavities are in close proximity to the thoracic duct.

The [illegible] nble very closely those of the pleura. [illegible] Thus, in expiration the lower and [illegible] e mid-axillary line as far as the 8th rib only, and posteriorly down to the level of the 10th dorsal spine. The anterior border of the left lung turns outwards along the lower border of the 4th costal cartilage, and, having crossed the 4th intercostal space, curves back across the 5th to the 6th cartilage, leaving a considerable area of pericardium separated from the chest wall by pleura only.

The relation of the longitudinal fissure of the lung to the chest wall is the same on the two sides; beginning from opposite the tip of the spine of the 2nd dorsal vertebra, it extends obliquely downwards and forwards across the 4th, 5th, and 6th ribs to the base of the lung at the 6th intercostal space. The transverse fissure of the right lung leaves the longitudinal fissure where it crosses the 4th intercostal space in the mid-axillary line, and passes forwards and inwards to reach the anterior margin opposite the lower border of the 4th chondro-sternal junction.

Root of the lung.—The roots of the lungs lie opposite the bodies of the 5th, 6th, and 7th *dorsal vertebræ*. *They are composed of the pulmonary* arteries and veins, the bronchi with the bronchial vessels in close apposition, lymphatic vessels and glands, and the vagus nerves with the larger posterior and smaller anterior pulmonary plexuses. The phrenic nerve descends in front of the root on either side; on the right the superior vena cava also lies in front and the vena azygos major arches over the root, while on the left side the arch of the aorta is a superior and the descending aorta a posterior relation. On either side the bronchi lie posteriorly to the pulmonary vessels. The artery on the left side is the highest structure crossing in front of the bronchus, and on the right the eparterial bronchus is still higher than the artery. The inferior pulmonary vein is the lowest structure.

Inside the lung the bronchi do not bifurcate, but give off a succession of larger ventral, alternating with smaller dorsal branches, which, subdividing into smaller bronchioles, terminate in the alveolar ducts. The alveoli are connected with these as a series of diverticula. The pulmonary arteries follow closely the divisions of the bronchi, ending in a single layer of capillaries between the alveoli.

The parietal pleura is innervated by the intercostal nerves with sensory and sympathetic fibres, while the diaphragmatic pleura receives in addition sensory fibres from the phrenics. The visceral pleura has no known nerve-supply. The pulmonary plexuses, composed of vagus and sympathetic fibres, embrace the roots of the lung and distribute branches along the bronchioles.

Movements of the lung.—The upper lobes (and, on the right side, the middle also) are expanded by the movements of the ribs and sternum. There is probably no alteration of the relative positions of the

surfaces of these lobes to the chest wall. The lower lobes are expande mainly by the descent of the diaphragm, and the surface of the lun moves downwards under the chest wall during inspiration.

Radiological examination.—No investigation of the chest ca be complete unless to the evidence obtained by clinical, pathological, an bacteriological methods is added that furnished by the X-rays. An X-ra examination includes radioscopy and radiography, and neither is complet without the other.

All radiograms, when possible, must be taken with the patient in th erect position. *With the patient in the recumbent position, free fluid, i present, will diffuse itself over the whole of the cavity* and cause a uniforml opaque shadow. It is *of paramount importance* that no respiratory move ments, either costal or diaphragmatic, take place, as otherwise the negativ *is blurred* and useless The radiogram should be taken with the breath hel *in the inspiratory position*, as this allows of the greatest contrast betwee *the various* structures.

SPECIAL METHODS OF OPERATIVE TREATMENT

Preliminary remarks on the physiology of pneumothorax with the open chest.—The lung is kept in contact with the chest wall in part by the negative pressure which exists in the potential space between the two membranes, and in part by the capillary attraction between the opposed pleural surfaces. The negative pressure is due to the elastic traction of the lung, and is equal to about 6 mm. of Hg. It varies slightly with inspiration and expiration; it is affected also to some extent by disease, being increased by acute changes (viz. massive collapse and, to a less extent, pneumonia), and by all diseases which cause fibrosis of the lung. The pressure may be decreased by emphysema.

If the pleural cavity is made to communicate with the external air by an opening of smaller size than the glottis, the lung collapses gradually, but the respiratory movements are not completely abolished, as during inspiration the air cannot enter through the small opening quickly enough to prevent some degree of negative pressure being established. When, however, the communication of the pleura with the atmosphere is larger than the aperture of the glottis, the lung on that side not only collapses but, with the mediastinum, is displaced towards the opposite side by the negative pressure of inspiration, and returns during expiration. A to-and-fro flapping of the mediastinum and its contents is thus produced, and this is the main factor of the dyspnœa, cyanosis, and irregular action of the heart which are the accompaniments of such an open pneumothorax.

Methods of overcoming disadvantages of operating with the open chest.—When the operation entails the making of a comparatively small opening into the lung, as for the purpose of draining an abscess cavity, it is possible, by stitching the circumference of the exposed parietal pleura to the underlying lung,

to fix the lung to the chest wall and so to abolish the dangers of an open pneumothorax.

This method is not applicable when a large opening has to be made into the pleural cavity for manual exploration of the lung, in cases of trauma, or for such operations as partial or total pneumectomy.

It has been found that so long as the lung is held by the hand or by instruments, and steady traction towards the opening is applied, the to-and-fro movements of the mediastinum are abolished. Similarly, if the pleural cavity is packed with gauze or towels, and the opening through the chest wall is obliterated as far as possible by the surgeon's arm and by towels, prolonged and extensive operations can be done without the great risk of death due to the mechanical and physiological disturbances associated with an open pneumothorax.

Operations done with the above precautions are perfectly justifiable when other and more refined means of compensating the open pneumothorax are not available. When, however, these other means are at hand they should be utilized, as they give the surgeon a greater freedom of action, remove the constant anxiety attendant on controlling the dangerous mediastinal movements himself, and facilitate the operation.

Hypo- and hyperatmospheric methods.—The fundamental principle of these two methods is the same, and aims at the compensation, when the chest is opened, of the normal intrapleural negative pressure, either by reducing the pressure of the air to which the surface of the lung is exposed or by increasing the pressure of the inspired air.

The Sauerbruch *unterdruck Kammer* consists of an air-tight chamber fitted with two doors separated by an air-lock, a system of ventilation, and a pump which keeps the air at a negative pressure of about 8 mm. Hg. The surgeon and his assistants work in the chamber. The anæsthetist is outside and in communication by telephone. The patient lies on a table with his head projecting through an air-tight opening in the wall of the room, and breathes, therefore, air at atmospheric pressure, while the lung, being exposed to a negative pressure, is under very nearly normal physiological conditions. In order to prevent the negative pressure exercising its influence on the veins of the abdomen and lower extremities, these parts are enclosed in a bag which is in direct communication with the air outside the chamber. There is no hypoatmospheric chamber in use in this country.

Of the various types of hyperatmospheric apparatus, that introduced by Meltzer and Auer has superseded all others This method of administering the anæsthetic under pressure is known as *intratracheal*

insufflation. Air, containing the anæsthetic and at a pressure regulated so as to keep the lung partially expanded, is supplied to the lungs through a catheter introduced through the glottis to just above the bifurcation of the trachea. The diameter of the catheter is about half that of the glottis (average size for an adult, 22 F.), and the excess of air escapes round the catheter and carries with it any mucus that may collect in the trachea and upper air-passages. The breathing of the patient is shallow, but oxygenation is satisfactorily maintained. Before the chest wound is completely closed, the pressure of the air is increased so as to inflate the lung on that side till it fills the pleural cavity. Normal respirations recommence almost immediately after withdrawal of the catheter.

DISEASES OF THE PLEURA

Nearly all injuries and diseases of the membranes are complicated by a dry inflammation of the pleura (dry pleurisy), or by the presence of gas or a liquid in the pleural cavity, which liquid has escaped from the lung or is an exudate from the membranes. Many of the symptoms and physical signs are due to the mechanical changes caused by the fluids; to these are added those due to inflammatory changes and those peculiar to the character of the fluid.

As an injury or a disease such as tuberculosis can be complicated by dry

of each rather than according to the disease.

Of the diseases of the lungs and of the pleural membranes, a certain number belong more to the domain of medicine than to that of surgery. There is, however, no single disease which may not require surgical intervention under certain conditions or on account of complications. No apology, therefore, is required for describing such conditions as pneumothorax or pleural effusion, seeing that they may equally well come under the care of the surgeon as under that of the physician.

ACUTE DRY PLEURISY

Dry pleurisy is characterized by one predominating symptom, pain. The pain is due to the friction of one inflamed membrane against the other. It is therefore most commonly felt over the lower part of the chest. It may be referred to the periphery of an intercostal nerve, and is then felt in the abdomen; this may lead to the erroneous diagnosis of an abdominal lesion.

When local applications and general sedatives, including morphia, have been tried and have failed (and the pain of acute pleurisy is often most

INTRAPLEURAL COLLECTIONS OF GAS OR LIQUIDS

1. Gas

(*a*) **Air** may be present in the pleural cavity as the result of—(1) operative interference; (2) injection for therapeutic purposes (air, nitrogen, oxygen); (3) diseases of the lung or of the pleura; (4) injury of the chest wall, bronchus, or lung.

When pneumothorax is secondary to disease of the lung, in 85 per cent. of the cases the primary lesion is phthisis. Suppurative conditions such as bronchiectasis, gangrene, and abscess are responsible for about 10 per cent.; while among the rarer causes may be mentioned emphysema and hydatid cysts.

The clinical picture depends on the suddenness of onset, on the condition of the lung, on the presence or absence of pleural adhesions, on the nature of the opening of communication with the atmosphere through the lung or the chest wall, and on the association of an accumulation of blood, serum, or pus.

If after the occurrence of a pneumothorax the opening of communication

tion of the air. In some cases, however, the opening is of a valvular nature, allowing air to enter the pleural cavity but not to escape from it; the result is a gradually increasing positive pressure associated with increasing displacement of the mediastinum, a condition known as ingravescent pneumothorax (*Spannungs-pneumothorax*) This condition produces intense dyspnœa and marked disturbance of the heart's action, and unless relieved is always fatal.

If the lung ruptures in the neighbourhood of an adhesion, the opening will be kept patent by the pull of the adhesion on one side and the collapse of the lung on the other. Such cases are always complicated by an effusion, which sooner or later becomes secondarily infected

The displacement of the mediastinum and compression of the opposite lung will be further increased if the pneumothorax is complicated by serum, pus, or blood.

When the pneumothorax is localized by intrapleural adhesions, but is otherwise uncomplicated, the disturbance produced by it is comparatively slight.

As a general rule, it may be said that cases of pneumothorax occurring with acute symptoms are due to some acute destructive lesion, since in the chronic processes consolidation and adhesions have probably occurred prior to the rupture. There is a small group of cases in which pneumothorax develops suddenly in an apparently healthy person: this is almost always due to rupture of a localized tuberculous cavity, rarely of an emphysematous bulla.

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inte

(b) **Gas of decomposition.**—In certain rare cases pneumothorax is due to gas-containing organisms. It is possible that in these conditions the infection is secondary : ...
abdomen, such as a subp...
dicitis, or a gastric ulcer ; ...
transudation or through a perforation.

(c) **Nitrogen or oxygen.**—As nitrogen and oxygen pneumothorax are produced under complete control, they are practically symptomless and need not be considered here (see pp 353, 377).

2. Chyle (chylothorax)

Few cases of chylothorax have been recorded, and in the great majority of these the diagnosis was made after exploratory puncture only.

Trauma involving the thoracic duct is the principal cause, but chylothorax may result from pressure on the duct by growths, tuberculous glands, or aneurysm, or from obstruction by thrombosis of the subclavian vein.

Unless the amount of chyle is sufficient to produce distress, aspiration must not be done, as the diminution in the intrathoracic pressure will favour reaccumulation. The probability of finding and successfully closing the opening in the thoracic duct by an open operation is slight. About 50 per cent. of the traumatic cases recover.

3. Blood (hæmothorax)

Etiology.—Trauma (including gunshot wounds) and rupture of an *aneurysm are the two chief causes of hæmothorax.* In traumata the bleeding may come from vessels in the systemic circulation (intercostal, internal mammary, aorta), or from the pulmonary circulation (injury to the lung). When hæmothorax is due to rupture of an aneurysm the diseased artery is usually the aorta, but may be the internal mammary. Rarely, rupture of a pulmonary infarct is the source of the blood. Hæmorrhagic effusion is occasionally found complicating diseases of the thorax (cancer and tuberculosis), Bright's disease, cirrhosis of the liver, and certain of the blood diseases, such as scurvy, purpura, and hæmophilia.

Symptoms and signs are those of pleural effusion, together with the symptoms, when the bleeding is severe, of internal hæmorrhage, viz ; pallor, coldness of the extremities, rapid pulse and respiration (the latter ...

pletely absent in another. During absorption there is usually fever and there may be jaundice.

Blood which is allowed to remain in the pleural cavity may considerably affect ...
fever, and ...
exertion. ...
sisting of fibrin and cells will become organized, and will to some extent interfere with the free expansion of the lung, and the completeness, therefore, of the patient's recovery.

Blood may act as an irritant and cause a serous effusion; or become infected and lead to an empyema (*see also* Lacerations of the Pleura and Lung, p. 362).

Treatment.

the intrapleural tension rises so as to produce great displacement of the thoracic contents and dyspnœa. The removal of two or three pints will temporarily relieve the symptoms. As, however, the liquid is likely to recur, it is advisable (if only for the patient's sake) to remove the whole of the liquid *so as to postpone the return of the symptoms as long as possible.* This complete removal can be done satisfactorily by oxygen replacement only. The intrapleural pressure left at the end of the replacement should be slightly negative.

4. Serous

(i) non-inflammatory (hydrothorax)

Etiology.—Hydrothorax develops in the course of chronic valvular disease of the heart, mediastinal tumour, aneurysm, cirrhosis of the liver, and nephritis. It may be unilateral or bilateral.

Symptoms and signs are those of pleural effusion (*see* below), *without any manifestations due to inflammatory changes.*

(ii) inflammatory (non-purulent)

Etiology.—Acute non-purulent pleurisy occurs at all ages, even in infants. It is in the great majority of cases associated with phthisis, sometimes with pneumonia; ... the presence of tuber-
culosis or carcinoma of
inflammatory focus, su

Symptoms and signs ... signs of acute pleural
...pression
..., and to

the displacement of the thoracic contents. There is often acute *pain,* localized in the side or referred to the epigastrium, or to the shoulder when the diaphragmatic pleura is involved. It is sharp or dragging in character, and is increased by any additional movement of the chest. Other symptoms
are cough,
the pulse a
cyanosis;
febrile conditions. There may be an initial rigor, ...
and vomiting. With the increase in liquid there is often decrease in pain, but the dyspnœa is progressive. When the effusion is large the patient lies on the affected side. The onset may be insidious. The intensity of the symptoms depends very largely on the rate of accumulation of the liquid.

Inspection reveals diminution or absence of the respiratory movements and enlargement of the chest on the affected side, obliteration (but rarely bulging) of the intercostal spaces, and displacement of the cardiac impulse.
... liquid and there
On perc
is increase
the axill.
sociated
e subclavicular region.

Auscultation.—The breath-sounds are diminished or absent over the liquid; rarely tubular breathing can be heard over the effusion as well as over the compressed lung. Bronchophony is usually present over the upper part of the chest, and ægophony can be heard at the upper limit of the liquid. Both in the early and subsiding stages a pleural or pleuro-pericardial friction rub may be heard.

Radiology.—The skiagram must be taken with the patient in the erect posture. The fluid gives a uniform opacity continuous with the diaphragm and rendering the latter invisible (as opposed to pneumonic processes in which the opacity of the diaphragm is distinguishable by its greater density from that of the consolidated lung). The heart and mediastinum are seen displaced to the opposite side

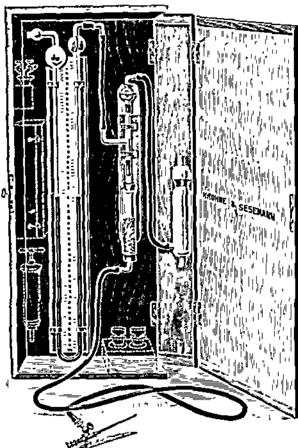


Fig. 722.—Author's apparatus for oxygen replacement of pleural effusions.

Treatment.—The liquid may be absorbed spontaneously, but if this does not happen, or if the liquid increases and produces respiratory embarrassment, *aspiration* is necessary.

The ordinary method of aspiration is very unsatisfactory, as it causes the patient considerable distress, and it is not possible to withdraw more than about half the total liquid present if the effusion is a large one. The remaining liquid may be absorbed, or it may act as an irritant causing a further outpouring of liquid. The persistence of the liquid may, moreover, be a barrier to the clinical and radiological diagnosis of the pulmonary condition. If, however, a second needle connected with an artificial pneumothorax apparatus is inserted into the liquid well above the aspirating needle, and if, every time cough or pain shows that the negative pressure produced by the aspiration is becoming too great, 100 c.c of oxygen are introduced, it will be found that practically the whole of the liquid can be withdrawn (together with a great

X

Blood may act as an irritant and cause a serous effusion; or beco infected and lead to an empyema (*see also* Lacerations of the Pleura a Lung, p. 362).

Treatment.—Hæmorrhage in connexion with traumata is consider in the section on Injuries (p. 361). Hæmorrhagic effusions, when they occ as a complication of some other disease, need not be interfered with unle the intrapleural tension rises so as to produce great displacement of tl thoracic contents and dyspnœa. The removal of two or three pin will temporarily relieve the symptoms. As, however, the liquid is likely t recur, it is advisable (if only for the patient's sake) to remove the whole c the liquid so as to postpone the return of the symptoms as long as possible This complete removal can be done satisfactorily by oxygen replacemen only. The intrapleural pressure left at the end of the replacement should be slightly negative.

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Symptoms and signs are those of pleural effusion (*see* below), without any manifestations due to inflammatory changes.

(ii) Inflammatory (Non-purulent)

Etiology.—Acute non-purulent pleurisy occurs at all ages, even in infants. It is in the great majority of cases associated with phthisis, sometimes with pneumonia; it may be due to injury or to the presence of tuberculosis or carcinoma of the pleura, or it may be secondary to a neighbouring inflammatory focus, such as pericarditis or subphrenic abscess.

Symptoms and signs [illegible]

[illegible] the displacement of the thoracic contents. There is often severe pain, localized in the side or referred to the epigastrium, or to the shoulder when [illegible] gging in character, [illegible] Other symptoms [illegible]

and vomiting. With the [illegible]
the dyspnœa is [illegible]
the affected side. [illegible]
depends very largely on the rate of [illegible] its

Inspection reveals [illegible] ly
and enlargement of th[illegible] bulging) of the intercostal spaces, and displacement of the cardiac impulse.

On *percussion* a dull wooden note is obtained over the liquid, and there is increased resistance. The upper level of diminished resonance is highest in the axilla. When the effusion is large a tympanitic note (skodaic resonance) associated with increased resistance is obtained over the compressed lung in the subclavicular region.

[illegible]

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Radiology.—The skiagram must be taken with the patient in the erect posture. The fluid gives a uniform opacity continuous with the diaphragm and rendering the latter invisible (as opposed to pneumonic processes in which the opacity of the diaphragm is d i s t i n g u i s h a b l e by its *greater density from* that of the consolidated lung). The heart and mediastinum are seen displaced to the opposite side.

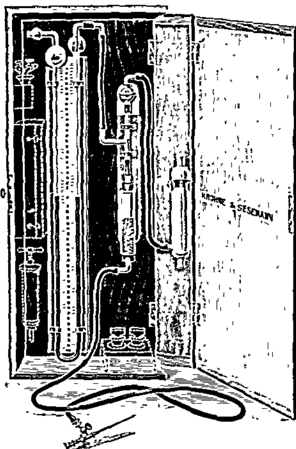


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is becom [illegible]
practica [illegible]

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Fig. 722 illustrates an apparatus I have had made for oxygen replacement of liquid. It consists of a manometer, filter and container. The manometer is connected by a T-piece, in the one direction (through a filter) to the needle, and in the other by way
the container. There ar
being connected with an
the air. During oxygen
through the container, filling it and escaping at the upper opening. If the needle is in the pleural cavity, and the tap between it and the container is open, oxygen is sucked into the pleural cavity (passing through the filter) when, and as long as, the intrapleural pressure is negative, and at a rate

cough, pain, dyspnœa and
ranes, acute œdema of the lung, sepsis, wound of an intercostal artery, and wound of the lung. With the exception of the last three, these are all associated with the rapid production of a negative intrapleural pressure. Acute œdema is a very dangerous complication, and may come on during, or an hour or two after, the operation.

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5. Empyema

Etiology.—Men are affected more frequently than women, and children more often than adults. About 45 per cent. of all empyemas occur in children under 10.

Of all causes, pleuro-pneumonia is by far the commonest. Approximately, it may be said that pleuro-pneumonia is responsible for 75 per cent. of the cases, and tuberculosis for 10 per cent. Other lung conditions, such as gangrene and abscess, bronchiectasis, and putrid bronchitis, are the predisposing condition in 5 per cent., traumata in 3 per cent., and the acute specific infections other than pneumonia in 7 per cent. Occasionally a pyothorax is due to a bacillus coli infection secondary to some suppurative focus in the abdomen. Still rarer causes are *Tænia echinococcus* and malignant tumours of the lung and pleura.

Morbid anatomy.—The liquid is thin and sero-purulent in character, or thick, containing much coagulated lymph, and rich in cells, while in the later stages the pus becomes inspissated. Occasionally in pneumococcic empyemas the effusion is almost solid. There is often a considerable deposit of fibrinous masses on the pleural membranes, and in chronic cases the pleura becomes thickened to an extent of even 2 or 3 cm. The empyema may be general, or localized by adhesions between the lung and the chest wall or between the lung and

the pericardium. The pus may be interlobar. With the increase in liquid the lung is collapsed and compressed round its root.

Symptoms.—The onset may be insidious; this is especially the case when empyema complicates a severe illness like pneumonia or broncho-pneumonia, or follows a simple pleurisy; then only the maintenance of the fever, the absence of a crisis, and the persistence of the physical signs in the chest and of constitutional symptoms suggest the presence of some suppurative complication. In some cases epigastric pain, tenderness, and vomiting are the earliest phenomena.

Fever is variable; either it may be slightly irregular with occasional sharp rises, or a rigor may be the first indication and the temperature remain high with considerable variations. In rare cases fever is absent. The constitutional symptoms are generally in proportion to the amount of fever present. There is often a constant hard cough which tends greatly to aggravate the pain. When present the pain is felt at the angle of the scapula, over the side of the chest, or is referred to the terminations of the intercostal nerves in the epigastrium. Dyspnœa is an indication of the rapidity of formation and amount of the effusion.

The **physical signs** are those of liquid in the chest, and vary with the degree of compression of the lung. In chronic cases, however, marked dullness associated with a small empyema is due to the great *thickening of the pleura; the breath-sounds are then faint and tubular.* It is important to bear in mind that the change in the physical signs caused by an empyema following immediately upon a pneumonia may be very slight.

An empyema may burst through the pleura and chest wall and form a large subcutaneous pulsating swelling—empyema necessitatis. The point of exit is usually between the 4th and 6th ribs, near the anterior axillary line; in children it is often as high as the 2nd interspace and on the front of the chest. The pus may burst into the lung.

Differential diagnosis.—It is often impossible to differentiate between a simple and a suppurative pleural effusion. If there is doubt an exploratory needle should be inserted into the chest. A simple effusion should show positive signs of subsidence after a fortnight. The presence of rigors or continuous fever, progressive emaciation, and constitutional disturbance unaccounted for by some primary lung disease, indicates that the effusion is an empyema. A large pericardial effusion producing dullness across the left base and signs of lung compression is recognized by the disappearance of the cardiac impulse, by muffling of the heart sounds, by dullness in the right 5th intercostal space, and by the character of the shadow with the X-rays.

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Empyema can be diagnosed from subdiaphragmatic abscess by the difference in level of the dullness. This with the patient sitting up is higher in the axilla than at the sternal border in the former condition, and lower in the latter. With the X-rays, a pleural effusion will appear as a dense shadow obscuring the diaphragm. In the case of a subphrenic abscess, the dome of the diaphragm is usually exaggerated and projects abnormally high into the thorax. A pleural effusion may, of course, complicate a subphrenic abscess.

Latent empyemas may be divided into two groups. In the one the condition is only recognized during systematic examination, sometimes only at autopsy. These cases occur mostly in children, and there is usually a previous history of an acute febrile illness, since recovery from which the patient has not been so well as before. The other group is that most often seen by the surgeon, and includes those cases in which the empyema—often latent as regards symptoms—perforates the chest wall. Diagnosis must then be made from caries of the rib, abscess associated with caries of the spine, gumma, and actinomycosis. The diagnosis can, in the first three conditions, be determined by X-ray examination. In actinomycosis pain is usually a more prominent feature. The character of the pus when aspirated or discharging from a sinus is characteristic (*see* pp. 368, 369).

If the pus has extended downwards and is involving the psoas muscle, the patient, usually a child, may be brought to the surgeon on account of limping.

Prognosis.—In cases that are left without operation, the pus *may very exceptionally* in mildly infected cases be absorbed or a small collection be enclosed in dense adhesions. Rarely, improvement results from rupture into a bronchus or lung. When an empyema bursts externally the result is invariably a fistula. Ulceration may occur into the œsophagus and stomach, or the pus may pass behind the diaphragm and enter the psoas sheath. Cerebral abscess is a complication in a small proportion of cases (*see* Bronchiectasis, p. 372). Delay in treatment will seriously affect the prognosis.

Treatment. Unilateral acute empyema.—A tuberculous effusion must not be treated by open operation, but by aspiration [illegible]

[illegible] especially in some of the [illegible]

[illegible] that do not yield to this treatment or are of the acute, [illegible] type must be dealt with like any other abscess, by *incision and drainage*. This is most satisfactorily accomplished by removing a portion of the rib; *in cases of great urgency*, however, the opening can be made through an intercostal space.

The patient must be placed either on his back with the affected side projecting over the edge of the table and the arm abducted to a right angle, or on the affected side. In no circumstances must he lie on the sound side, as the increase to the respiratory embarrassment may produce an immediately fatal result. The pleura should be opened at the level of the 8th or 9th rib, in order to drain the cavity as low as possible while avoiding the formation of an oblique sinus by the subsequent approximation of the diaphragm and chest wall during healing. After an exploring needle has been introduced to establish the presence of pus at the level of the proposed operation, the rib is exposed, its periosteum reflected from both inner and outer surfaces, and about 5 cm. of the bone is excised with bone-forceps. A vertical skin incision 6–8 cm. long, between the scapular and posterior axillary lines, with retraction of first one side and then the other, affords easy access and is preferable to the ordinary incision along the course of the rib. When, at the end of the operation, the arm comes to the side, the oblique wound may be found to be below the pleural opening and a vertical additional cut will be necessary to accommodate the tube; moreover, the fibres of the latissimus dorsi are cut across in the oblique incision, the muscle is split in the vertical. The posterior layer of the periosteum and the pleura are incised above the intercostal vessels, which, if not already thrombosed, are divided between ligatures. The escape of pus must be controlled to prevent too rapid alteration of the intrathoracic pressure. The interior of the pleural cavity is now explored with the gloved finger to ascertain the amount of re-expansion of the lung and the condition of the pleura, and to discover and remove any large masses of lymph which might obstruct the drainage-tube. In empyemas on the left side, particularly, the condition of the pericardium should be ascertained, as a pericardial effusion is a not infrequent complication. If the intercostal artery is injured during the division of the rib and cannot be picked up with artery forceps, a ligature or suture passed round rib and artery will arrest the hæmorrhage. The cavity should not be irrigated during the operation, as this procedure sometimes produces a fatal syncope.

To drain an empyema without resecting a portion of the rib, the incision is made through the intercostal space along the upper border of the 8th or 9th rib. But the intercostal space does not usually permit of an opening large enough for satisfactory drainage, and the pressure of the tube may cause infection of the neighbouring ribs and secondary hæmorrhage from an intercostal artery.

If the empyema is localized, and does not extend below the 9th rib posteriorly, the opening should be made into the lowest part of the cavity, as determined previously by percussion and radiography.

Re-expansion of the lung and re-apposition of the layers of the pleura.

—If the lung is collapsed only and not consolidated, *evacuation of an acute empyema will be followed by re-expansion.* If consolidation, fibrosis, or thickening of the pleura prevents complete re-expansion, approximation of the visceral and parietal pleura may yet be possible through shrinkage of the chest wall, approximation of the ribs, and displacement of the mediastinum and diaphragm towards the affected side. To encourage the re-expansion of the lung, some surgeons advocate the use of apparatus devised to drain the empyema and to exert at the same time a constant negative pressure.

Postoperative treatment.—Occasionally after opening an empyema there is a short, dry, distressing cough; for this *morphia in small doses* should be given. The most essential part of the treatment is the prevention of secondary infection of the pleura by pyogenetic organisms. Persistence of a cavity or fistula is frequently due to such "double" infection. If the cavity is draining properly the secretion will become more serous in character, and healthy granulations will be seen lining the opening. As the discharge decreases, a small tube may replace the original one about a fortnight after the operation, and in another week in a normal postpneumonic case the tube may be replaced by gauze. Persistence of a fistulous track through the chest wall is not infrequently due to the too long retention of a drainage-tube.

The time of healing varies from four to eight weeks, and is generally more rapid in children than in adults. When possible, the patient should be moved out of doors during the day, after about the third day. The sooner he gets up and moves about the more complete will be the re-expansion of the lung; he may usually be permitted to do so by the beginning of the second week. Exercises such as blowing water from one Woulfe's bottle to another are also of value in promoting full lung expansion.

Double acute empyema.—When this condition exists, excision of rib and drainage of the pus should be done on the side showing the greater compression, and the pus aspirated by the oxygen replacement method from the opposite side. If the lung on the side which has been opened re-expands *fully, the opposite pyothorax may then be* properly drained. In some severe cases, however, resection on the one side and aspiration on the other side does not produce the necessary relief; then both sides of the chest should be opened and drained. This is possible owing to the fact that both lungs are fixed to a greater or *less extent by adhesions.*

CHRONIC EMPYEMA

Chronicity is due to one of three causes:

1. The nature of the disease: tuberculous or actinomycotic *infections*; growths invading the pleura; or bronchial fistula.

2. Delay in diagnosis owing to the presence of pneumonia or of symptoms not pointing directly to the chest.

3. Imperfect drainage from an opening either inadequate in size or badly placed; sepsis or the presence in the cavity of a source of continued infection, such as an undrained loculus, a drainage-tube which has slipped into the cavity, or caries of a rib.

Associated with all these is the rigidity of the chest wall, more marked in adults, tending to prevent obliteration of the cavity. For such cases a thoracoplasty is necessary, with or without decortication or discission of the thickened visceral pleura.

Treatment. — There are two types of operation: the one consists of a resection of parts of two or more ribs through oblique incisions (Estlander); the other, of the removal of several ribs together with the intercostal muscles and underlying pleura, access being obtained by turning up a big flap (Schede). In every case of chronic empyema the operation of thoracoplasty must be planned to suit the size of the cavity, and sufficient rib removed to allow of complete collapse of the outer wall. Thoracoplasty is described at p. 387.

Decortication was first practised by Delorme and Fowler. The chest is opened and an incision made through the visceral pleura, which is often 1 to 2 cm. thick, until the blue colour of the lung is observed. The pleura is then stripped off the surface of the lung, which will probably at once re-expand.

Discission was originated by Ransohoff as a simpler procedure than decortication. The pleura in this operation is not stripped off the lung, but is divided by a series of longitudinal and vertical incisions about ¼ in. apart. This method has not, however, won very general acceptance.

To summarize the treatment of a chronic empyema:

1. The nature of the infection must be ascertained and the possibility of a foreign body or carious rib considered.

2. The opening, almost certainly insufficient for the purposes of drainage, must be enlarged so as to admit of complete exploration of the cavity.

3. Unless the primary disease be tuberculosis or actinomycosis, or some irritant focus be found, the cause of the non-closure is in all probability sepsis, the thickening of the pleura associated with lung collapse and the rigidity of the chest wall.

4. According to the size of the cavity, some form of thoracoplasty, with or without decortication or discission, must be done.

Irrigation of the cavity in the treatment of chronic empyemas is rarely beneficial, and may produce symptoms of distress unless two openings are made, that for the escape of the fluid being considerably larger than the inlet.

CALCIFICATION OF THE PLEURA

Pathology.—Following on old chronic inflammations, deposits of calcium salts occasionally take place either in the thickened pleura or in the walls of encysted collections of pus. As a result, calcareous masses, covered by a layer of fibrous tissue, are formed; these consist of plates, irregular in shape and size, of stalactites penetrating into the lung, or of a hood capping the apex.

Symptoms and physical signs.—There may be either no clinical indications of the condition, or a certain degree of respiratory insufficiency [illegible]

Treatment.—Unless there is much impairment of respiration no surgical interference is necessary. If operation is undertaken the plates must be completely removed, else a chronic sinus will result.

HYDATID OF THE PLEURA

Only about 2 per cent. of hydatids of the thorax originate in the pleura. As the symptoms and physical signs, and also the treatment, are so closely similar to those of hydatid of the lung, the two conditions are dealt with together in the section on Diseases of the Lung (p 382).

TUMOURS OF THE PLEURA

Pathology.—Tumours secondary to growths primary in other organs have no surgical interest. Primary tumours are rare.

Simple tumours are fibroma, lipoma, and angioma, but only a very few cases have been recorded The lipomas are of two varieties: those growing in connexion with the fat in the intercostal spaces, and those developing fro[illegible] the diaphragm. [illegible] hese probably only extend int[illegible]

Of malignant tumours, the sarcomas, round-, spindle-, and mixed-celled, of which 29 cases are recorded, *and carcinoma, which is very rare*, are the most rapidly fatal. Less malignant are endothelioma and fibro-sarcoma *myxomatodes*. The endotheliomas are the commonest of the pleural new growths. They may occur as a single tumour, as scattered nodules, or as a diffuse mass involving the whole pleura. Microscopically, they consist of fib[illegible] polymorphous cells; as they in[illegible]

Symptoms and signs.—[illegible] *hs give few signs other than* a[illegible] -sounds, unless the tumour reaches *so large a size as to produce* displacement of the heart and collapse of the lung. A pleural effusion is often associated with malignant growths, [illegible] when [illegible] ing, [illegible] phy [illegible] e p. 353.)

Pain is generally present; dyspnœa is in proportion to the amount of compression of the lung.

When the tumour is large there is bulging of the corresponding part of

the chest, and rarely the growth extends through the intercostal spaces and becomes subcutaneous

Treatment. [illegible]

tress occasioned by the accumulation of fluid must be relieved by aspiration with oxygen replacement.

INJURIES OF THE PLEURA AND LUNG

Injuries should not be classified according to the cause, but should be considered according to the type of lesion, i.e. to the morbid, pathological, and mechanical changes produced. It is necessary therefore to consider—

A. The changes and effects produced by—
  (1) Compression of the chest.
  (2) Contusion of the pleura and lung. With these must be considered the complications due to infection and those due to fractures of the bony framework.
  (3) Lacerations of the lung.

B. Laceration of the chest wall causing communication between the outer air and the thoracic contents.

C. The complications arising from injuries to adjacent organs and structures.

A. (1) COMPRESSION OF THE CHEST

In children, owing to the resiliency of the chest, fractures are much less common than in adults. Compression produces an increase in the intra- [illegible]

produce the condition known as *traumatic asphyxia*. This is the name given to the symptom-complex resulting from the sudden rise in the intrathoracic pressure driving back the blood from the veins into the capillaries, which rupture and so cause an extravasation of blood. The extravasation affects mostly the upper part of the chest, the neck, face, and to a less extent the upper limbs. Subconjun[illegible]
Extravasation below the [illegible]
space available in the ve[illegible]
will prevent the extravas[illegible]
[illegible] For the same reason, [illegible]
ten days.

When a bronchus is ruptured the opening is extrapleural, and the air escapes into the mediastinum, causing mediastinal emphysema (see p. 362).

A compressing force applied antero-posteriorly tends to bend the ribs so that they break outwards. One exerted laterally, or a direct blow, will drive the ribs inwards, and the fractured ends will damage the pleura, and probably the lung as well. Contusion or laceration of the lung renders the

affected part of this organ much more susceptible to the inroad of infective organisms.

(2) CONTUSIONS OF THE PLEURA AND LUNG

Contusions of the pleura cause either a dry pleurisy or a pleurisy with effusion.

ance, and some rise of temperature. The grave sequelæ which may occur are due to the damage to the tissues which allows of the proliferation of organisms normally present in the air-passages. This may lead to pneumonia, lobar or unilateral in character, or, in severer cases, to abscess and gangrene.

Massive collapse has been most frequently observed after gunshot injuries and after a general anæsthetic. It consists of a sudden great diminution in the size of a lobe or a lung, which becomes collapsed and useless. As a result of the collapse there is a high intrapleural negative pressure with acute displacement of the mediastinum to that side, raising of the diaphragm, and falling-in of the chest wall.

The **symptoms** *are pain, great dyspnœa, cyanosis, rapid pulse, and* possibly collapse of the patient. The **signs** are diminished movement, increased resistance, weak breath-sounds and tubular breathing over the area *affected.* These manifestations usually clear up with surprising rapidity after 24–48 hours.

... understood. ... espiratory ... (3) acute reflex spasm of the musculature of the bronchioles, (4) œdema of the mucous membrane, combined possibly with one or other of the above changes.

(3) LACERATIONS OF THE PLEURA AND LUNG

Laceration of the pleura produces the same manifestations as contusion of that membrane. In addition, there are four possible complications: (1) *Surgical emphysema: When the lung also is injured,* air can escape into the cellular tissues of the chest wall. In severe cases it may spread along the intermuscular planes and involve the face, into the upper limbs to the wrist even, *and into the lower limbs to the ankles. It imparts* a fine crackling sensation when the skin is pressed. It may cause discomfort, but is in itself not a serious matter. (2) *Mediastinal emphysema,* due to injury of the lung and mesial reflection of the pleura, or *to extrapleural rupture of a bronchus,* is a much more dangerous phenomenon, as the air causes compression of the structures in the mediastinum, and especially of the veins. This results in ... *of the face and neck,* and heart- ... intercostal or mammary artery ... ly external evidence of bleeding. ... spread of *infection from a septic* ... in the chest wall into the pleural cavity.

the lung, from a septic wound in the chest wall, ... trating from without and carrying in fragments of clothing or other infected

toxæmia, and on aspiration a sterile liquid only is withdrawn. The toxæmia increases, and then suddenly there is an acute flare as the organisms infect

...fection, but there is the possibility that fragments of bone may be driven into the lung parenchyma. These are particularly dangerous, as they may cause primary or secondary hæmorrhage, and nearly always lead to infection. Hæmorrhage in another area of the same lung or in the opposite lung may occur by *contre-coup*. *Sphacelation*, or the sloughing off of a portion of lung substance, is a rare complication.

Treatment.—The three most important considerations are the treatment of shock, the arrest of hæmorrhage, and the prevention and limitation of infection. Morphia should be given, as it will reduce or abolish pain, and so help to combat shock; at the same time it will quieten the patient and assist in the arrest of hæmorrhage. If the continued loss of blood is endangering the patient's life, it must be ascertained whether the bleeding is systemic or pulmonary, and steps must be taken accordingly to control the bleeding.

Fractures.—Serious displacement of fractured ribs is rare, and union occurs easily. Limitation of movement of the side, to alleviate pain, is of most importance. Strips of plaster should be applied, each overlapping the other, and extending from well below to well above the broken ribs. Each strip must encircle the whole half of the chest and also extend 2 inches beyond the middle line back and front.

Pleurisy.—The treatment of dry pleurisy has been dealt with on p. 348, and of pleural effusions on p. 353.

Hæmothorax.—*Recent aseptic hæmothorax.*—The necessity for the complete removal of a pleural effusion has already been emphasized (p. 353), This necessity is still greater in a hæmothorax because of the heavy deposit of fibrin and cells. The treatment, therefore, is the complete removal by oxygen replacement (*see* p. 353). This can be done without fear of a recurrence if, during the first week after the injury, the intrapleural pressure left is not lower than equal to 1 mm. of mercury. After the first week a negative pressure equal to 5 or 8 mm. can be left with safety.

Incomplete absorption.—Aspiration is impossible, as the cannula becomes blocked by the gelatinous clot. The whole clot must be removed through an opening low down in the chest wall, made by resecting a length of rib or, better, by incising along an intercostal space When the clot has been evacuated and the pleural cavity mopped out, the wound must be very carefully and completely closed so as to make it air-tight. The air in the cavity should then be replaced by oxygen and a negative pressure equal to about 12 mm. of mercury left. This will help to prevent the accumulation of a serous effusion and will assist the lung to re-expand.

Infected hæmothorax.—This must be treated like an empyema. Especial care must be taken to ensure that any foreign body which may be lodged in the pleural cavity is removed. When a clot of blood has been formed round

Symptoms and history.—The symptoms occur either during the course of some other disease or in a person previously apparently healthy. The onset is not very abrupt, and manifests itself by a feeling of malaise which steadily increases. The temperature rises and is irregular, and there may be an initial rigor.

Cough develops, and may be accompanied by pain and by a "catching" in the affected side of the chest. There is dyspnœa, occasionally profuse sweating, prostration, perhaps cyanosis. When the abscess bursts into a bronchus there is a severe fit of coughing accompanied by profuse purulent, usually stinking, expectoration. If the sputum is offensive the patient suffers from a filthy taste in the mouth. Occasionally the bad taste and the odour of the breath are present before there is any expectoration. In some cases hæmorrhage accompanies the rupture of the abscess, or later there is repeated hæmoptysis. The patient often prefers to lie on the affected side.

The character of the sputum is generally diagnostic. In colour it is usually dark-brownish-red, thin and watery, containing pus cells, blood pigment, fat droplets and fatty-acid crystals, shreds of fibrous and elastic tissue, and numerous and varied bacteria. The presence of the shreds is of importance in differentiating this condition from putrid bronchitis and external abscesses which have burst into the lung. As much as 500 c c. may be expectorated in the first twenty-four hours. If the expectoration is allowed to stand it will settle in three layers; the lowest will consist of pus, the intermediate will be watery and turbid, and the upper one composed of frothy mucus with shreds. In some cases, especially those secondary to septic emboli, the sputum shows a characteristic series of changes corresponding to the condition of the affected lung. For example, immediately after the lodgment of an embolus it may consist of blood-stained mucus due to infarction; later it may be the rusty viscid expectoration of the developed pneumonia, which in turn is gradually replaced by stinking pus.

Physical signs.—These vary very considerably, as they depend on the position of the abscess and the amount of surrounding infiltration.

Pain and diminished movement of one side of the chest may be the only localizing indications.

When the abscess is near the surface or the accompanying pneumonic change is extensive, the *percussion note is dull over that area, often so* much so as to suggest the presence of an empyema; but when the cavity is deeply placed *the note is tympanitic.* Together with the impaired resonance are weak breath-sounds, often bronchial in character, or tubular or *amphoric breathing* is heard, and in the centre of the area the post-tussic suction sound can frequently be obtained. In the neigh-

bourhood are numerous fine râles. When the pleura is implicated the signs of pleurisy, with or without effusion, are superadded.

If the process of destruction and septic absorption is very rapid the urine contains increasing quantities of albumin, the heart becomes progressively weaker, and delirium is associated with a high fluctuating temperature. In the subacute and chronic states the temperature is but little raised, and the toxic and constitutional conditions are less marked.

Radiography is of the greatest importance in revealing the situation, depth, size, and number of the lesions. Three types of shadows may be seen:

1. A well-defined shadow in a clear field—chronic abscess.
2. The dark shadow of the abscess surrounded by a less opaque area due to the surrounding hepatization. A deep inspiration often lessens the outer opacity, and a cough, if it succeeds in emptying the abscess cavity, will change the central shadow into a light patch (Plate 118, Fig 1)—acute or subacute abscess.
3. A diffuse opacity. This suggests that the lesion is very acute and is spreading rapidly. By deep inspirations and coughing, however, the actual position of the abscess can sometimes be localized.

Differential diagnosis.—The sudden outpouring of pus from the lungs suggests either lung abscess or gangrene, bronchiectasis, or rupture into the lung of pus from an empyema, subphrenic abscess, mediastinal abscess, or suppurating hydatid cyst. In these cases there is also the same tendency for the expectorated material to settle in three layers. But in gangrene and abscess alone is the constant presence of the elastic fibres and tissue shreds noticeable. The character of the shadow of the pus-containing cavity and its relation to the clear area of lung and to the diaphragm are also of great value.

Prognosis.—Rarely an acute abscess heals spontaneously after rupture into a bronchus. The mortality of cases treated by the expectant method is 75 to 80 per cent, while in a considerable number of those patients who survive the acute stage the abscess becomes chronic, with persistence of symptoms and the constant danger of hæmorrhage, empyema, and metastatic abscesses. In cases treated by operation the mortality is 30 per cent. only.

The prognosis of chronic abscess is less satisfactory.

Treatment.—An acute abscess associated with high temperature, foul breath, and marked constitutional disturbance must be opened as soon as possible. If the symptoms are not so severe or the pus is discharging freely through a bronchus, the urgency for pneumotomy is less marked, but in either case operation must be undertaken if the condition becomes stationary or the symptoms progress. (For details of thoracotomy and pneumotomy, *see* p. 389.)

Preliminary puncture is to be deprecated, as it is attended with the dangers of pleural infection or of continuous bloody expectoration and cough.

The main difference in the treatment of acute and chronic cases is that in the former free opening and drainage alone are necessary, but in the latter drainage must be supplemented by removal of all the overlying and adjacent ribs, else, owing to the rigidity of the abscess wall and thorax, complete obliteration of the cavity by approximation of the walls will not be obtained.

The possibility of secondary neighbouring foci must always be borne in mind. If known to exist, but not readily found at the operation, they should be left for a few days, when they may burst into the main cavity.

The after-treatment of the pulmonary abscess is similar to that of abscess elsewhere, i.e. the wound must be kept widely open and allowed to granulate from the bottom.

When there is a single chronic abscess complicated by dilatation and distortion of the bronchi, or the abscess is a complication of bronchiectasis (Plate 118, Fig. 2), or a lobe contains multiple small abscesses, incision and drainage will fail. It becomes necessary in such cases to obtain an extensive collapse of the whole of the affected area by a large thoracoplasty (p. 387) or by rib mobilization (p. 388).

BRONCHIECTASIS

Bronchiectasis is a *chronic affection of the bronchi and bronchioles*, resulting in dilatation, thickening, and rigidity of these tubes.

Etiology.—*It is found most frequently* in early and middle adult life, and in males more than in females. Rarely it occurs as a congenital condition.

It is not a disease *sui generis*, but is the result of abnormal mechanical changes in the lung parenchyma or of mechanical interference with the free passage of air. According as it develops during the course of some pre-existing disease or at an interval after the subsidence of the original lesion, bronchiectasis must be regarded either as a complication or as a sequela.

Bronchiectasis occurs—

(1) As a *complication* of—

(*a*) *Atelectasis* of the lung, "congenital bronchiectasis."

(*b*) Any chronic affection of the lung, such as phthisis or chronic abscess.

(*c*) Pressure on a bronchus from without as a result of aneurysm, enlargement of lymphatic glands, chronic interstitial mediastinitis, or foreign body (shell fragment or bullet).

Fig 1 —Gangrene of right upper lobe of lung.



Fig 2 —Chronic abscess with bronchiectatic changes due to fragment of tooth. Treated by artificial pneumothorax.

PLATE 118.

(*d*) Chronic obstruction of the lumen of a bronchus by intra-bronchial neoplasm.

(2) As a *sequel* of—

(*a*) An acute infection of the lung, such as pneumonia which fails to undergo complete resolution.

(*b*) An acute infection of the lung, such as occurs as a result of gunshot wounds.

(*c*) Acute irritation of a bronchus, such as is produced by exposure to shell gas.

(*d*) Acute obstruction of a bronchus by a foreign body.

Morbid anatomy.—From the surgical standpoint three types of bronchiectasis must be described:

1. The disease is localized to part of a lobe, but involves the surrounding parenchyma and produces an abscess.

2. The disease spreads throughout the large and small bronchial tubes of one lobe, usually the lower, but produces little change in the surrounding lung tissue other than a localized fibrosis.

3. The disease is unilateral, and involves the majority of the bronchial tubes, producing considerable dilatation of these and an extensive fibrosis of surrounding lung tissues. As the result of this latter the mediastinum is drawn across to the affected side, the diaphragm is drawn up into the expiratory position, and the ribs on the affected side are closely approximated.

When the bronchiectasis is bilateral and involves several lobes the condition is not accessible to surgical treatment.

Symptoms.—The characteristic feature is the intermittent cough accompanied by the expectoration of considerable quantities of sputum, which may be comparatively inoffensive or extremely fetid. This intermittence is due to the acquired tolerance of the affected tubes, but when some change in posture or an overflow allows the accumulated secretions to stimulate the adjacent mucous membrane an attack of coughing results. Occasionally there is hæmoptysis.

Physical signs.—Flattening and diminished movement of the chest, impairment of resonance, and imperfect air-entry are usually found over the affected area. The character of the breath-sounds, however, and the presence of râles vary with the extent of the dilatation and distension of the bronchial tubes.

Clubbing of the fingers is more commonly associated with bronchiectasis than with any other lung disease.

Radiology.—This is of immense value, as it not only confirms the nature of the disease, but shows with great precision the extent and character of the primary lesion and of the secondary changes in the parenchyma of the lung.

In the unilobar type the radiogram shows radiating dense shadows

extending from the hilum to the periphery of the lobe (Plate 119, Fig. 1). In more advanced cases these shadows become confluent when the bronchi are full of pus; after expectoration a number of clearer rounded areas are visible. In the unilateral cases the whole lung is represented by a dense shadow.

Complications.—Heart-failure and amyloid disease appear in the later stages. Ulceration of the bronchi leads to gangrene, but the commonest causes of death are broncho-pneumonia (27 per cent. of cases) and cerebral abscess (20.5 per cent.). Shorstein's statistics show that "bronchiectasis is the most frequent pulmonary antecedent of cerebral abscess," and is responsible for 55 per cent. of the cases, empyema for 22 per cent., pulmonary gangrene and abscess for 11·5 per cent., and tuberculosis for 4.5 per cent. The cerebral abscess was single in 62 per cent., and of these the ratio was 3.5 in the left cerebral hemisphere to 1.0 in the right.[1]

Prognosis.—It is very seldom that medical treatment can do more than produce a temporary improvement. The results of surgical intervention are more encouraging. About 5 per cent. of cases are cured, while a very large percentage are permanently alleviated.

Treatment.—Bronchiectasis, whether it is associated with an interstitial abscess or not, must never be treated by an open operation. *Rib resection* and *rib mobilization* (Fig. 723), as described at pp. 387, 388, are the most satisfactory methods of treatment. By the collapse of the lung which is obtained, they obliterate the dilated spaces in the lung and so abolish the retention of secretions and all the symptoms which are due to it. The results obtained are permanent. (Plate 119, Fig. 2.)

Either of these operations should be preceded, whenever possible, by production of an *artificial pneumothorax*, since, in the first place, the collapse will reduce the toxæmia and so enable the patient to tolerate better the major operation. In the second place, the danger of flooding the lungs with pus when the collapse of the lung and chest wall occurs will be greatly reduced.

If the major operations are declined, or are contra-indicated, artificial pneumothorax should be attempted. But the collapse of the lung, brought about by this means, must be maintained during the remainder of the patient's life, else the symptoms will return as the lung, and consequently the dilatations, are allowed again to open out. In a recent case which I treated in this way, the compression of the bronchiectatic abscess by the gas expelled a fragment of tooth which had been in the lung for ten years. (Plate 118, Fig. 2.)

[1] In one case I have seen bronchiectasis complicated for a short time by massive collapse. Radiograms illustrating this condition are shown in my book on "Diseases of the Lung and Pleura."

Fig. 1—Bronchiectasis of the right lower lobe. Note the well-marked shadow at the hilum of the left lung due to commencing involvement of the larger bronchial tubes.

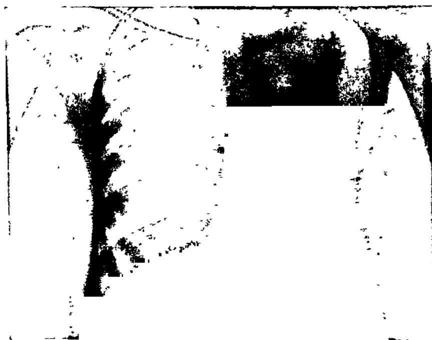


Fig. 2—Bronchiectasis in girl æt 12. Treated by rib resection by posterior incision. (*Author's case.*)

PLATE 119.

In unilobar cases, ligature of the branch of the pulmonary artery supplying that lobe has produced very satisfactory results (*see* p. 390). For bronchiectasis of the lower lobe, paralysing the diaphragm by section of the phrenic nerve and local rib resection will cause collapse



Fig. 723.—Photograph of a boy aged 10, taken one month after operation of rib mobilization (Wilms) for extensive bronchiectasis of the whole of the left lung. The scar (which has been emphasized) is in close apposition to the spinous processes of the vertebræ. (*Author's case.*)

sufficient greatly to diminish if not actually to abolish the symptoms (*see* p. 387).

TUBERCULOSIS

Surgical treatment of pulmonary tuberculosis differs from surgical treatment of other parts of the body in that it is not a substitute for medical treatment; it must be regarded as an accessory. This is particularly obvious when there is associated disease of the opposite lung, and possibly even of the larynx as well. Neglect in building up the general resistance of the body; neglect in the recognition of the possible failure of one or more of the endocrine glands; neglect in the treatment of intoxication from intestinal stasis; neglect in the attention to dental sepsis and other forms of constant infection are all, or any of them, likely to lead to disappointment, by impairing the efficacy of treatment by surgery. In the induction of artificial pneumothorax, for instance, complete failure may be due not only to the inability of the lung to collapse, but to the complications caused by B. coli and streptococcal infection, when those are uncontrolled by special measures.

The importance of correct diagnosis is an obvious and accepted fact, but the fallibility of clinical methods (due either to the absence of them) culty of correctly interpreting physical signs or to the absence of them) has not yet been completely realized. Tuberculosis must be diagnosed from syphilis, streptotrichosis, and bronchiectasis Hæmoptysis may be due to any of these three conditions and also to hydatids, abscess, or carcinoma. No case should be treated by operation until a radiological examination has been made, so as to control and amplify the observations already collected. When surgical treatment is indicated, artificial pneumothorax should always be the method used—if practicable. The other, and severer, types of operation should be reserved for those cases only in which the pneumothorax has been found to be impossible owing to adhesions.

Artificial pneumothorax.—The object of this procedure is to displace and compress the lung against the mediastinum. (Plate 120, Fig. 1.) The lung is not collapsed into a ball round the hilum, as happens with a healthy lung in traumatic pneumothorax, but, owing to the rigidity of the bronchial tubes, becomes compressed as a band along the length of the mediastinum. The result of this compression is to put the lung completely out of action and to immobilize it by the pressure of gas on its outer, anterior and posterior surfaces. All spaces (cavities or dilated bronchi) are thereby obliterated; retention of pus or of infected mucus is prevented, hæmorrhage is impossible, the fibrous tissue due to the pathological changes is relaxed and can contract without exerting a harmful influence; while, so far as that lung is responsible for these symptoms, all cough, sputum, signs of intoxication,

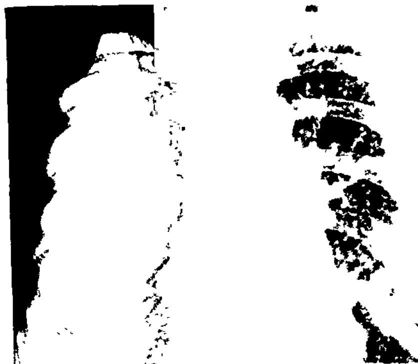


Fig 1 —Collapse of lung on the right side produced by artificial nitrogen-pneumothorax

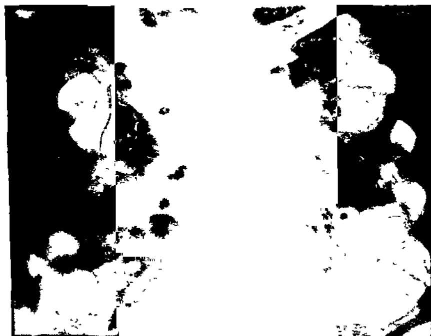


Fig. 2.—Bilateral artificial pneumothorax in a very advanced case

PLATE 120.

risk of the spread of infection by ejected or swallowed tubercle bacilli, dyspnœa, and fear of hæmorrhage are abolished.

The displacement and compression of the lung are obtained by nitrogen or by air. The former is preferable, as the oxygen in the air is very rapidly absorbed, and no oxygen will be found in the pleural cavity after about four days. It would appear that the pleural membranes are capable of producing a constant interchange of gases in the pleural cavity. Whatever gas is introduced, after a few days nitrogen and carbon dioxide in the proportion of about 95 per cent. and 5 per cent. are found. If oxygen only has been run in, the pneumothorax produced will diminish much more rapidly than if nitrogen is used The rate of disappearance of a pneumothorax depends also, however, on the capacity of the lung for re-expansion, which may be limited by fibrosis in the lung itself or by thickening of the visceral pleura. As the atmosphere contains 20 per cent. of oxygen, it follows that if, say, 500 c.c. of air are introduced, only about 450 c.c. are available for maintaining the pneumothorax for any appreciable length of time. A further objection to air is that the injection of gas into the pleural cavity is often followed by a "reaction." One factor in determining the degree of reaction is the amount of gas put in (i.e. really the amount of displacement of the lung produced) This means that a reaction equal to 500 c.c. of gas is produced for a real value of about 450 c.c. when air is used in preference to nitrogen.

The rate of absorption varies greatly with different individuals. Because of this, constant radioscopic examinations are necessary to determine the frequency with which the absorbed gas must be replaced (i.e. the intervals at which the "refills" should be given). The occurrence of an effusion—and its subsequent absorption—may delay absorption of the gas by changes in the pleural membranes.

Reaction and its causes.—A reaction is the rise of temperature associated with malaise which occurs, in some patients constantly, in others only occasionally, after displacement of the lung by gas. There are two main causes of the reaction.

(1) *Absorption of tuberculous products from the lung.*—This reaction appears during the ensuing twenty-four hours as a sharp rise of temperature which subsides in the course of two or three days. Such reaction can be to a great extent controlled by the amount of gas introduced (i.e. by the amount of displacement of the lung). Patients who show this susceptibility to absorption of tuberculous products will, as a rule, have some reaction after every injection of gas until the disease is quiescent. Provided too big a reaction is not produced (and such a one might cause extension of the tuberculous trouble), there is no evidence that it produces any harm.

(2) *Absorption of toxins from the intestinal tract.* (*a*) *B. coli infection.*—The temperature rises rapidly in these cases also, but will take some three to five days, or even longer, to subside. The feeling of malaise and nausea is much greater than with a tuberculous reaction, and there may be general aching in the limbs. The tongue is always coated, and there is considerable anorexia. If the urine is examined it will be found to contain large quantities of sulpho-ethers. Such a reaction is very liable to be accompanied by an effusion into the pleural cavity under treatment, while the constant recurrence of these symptoms will greatly debilitate the patient and may unduly delay the artificial-pneumothorax treatment. The importance of preventive treatment in patients suffering from intestinal stasis and in whom there is a flare-up of the bacillus-coli infection after an injection of gas, cannot be overestimated. The most efficient prophylaxis is afforded by thorough purgation by castor oil or calomel on the day preceding the injection. In the intervals of artificial-pneumothorax treatment, every care should be taken to prevent the colon from becoming loaded or obstructed.

(*b*) *Streptococcal infection.*—This is a rarer but more serious complication. The chief characteristics are: (1) The swinging temperature —a gradual rise and fall extending often over a period of ten days or more, and sometimes repeated just as the temperature appears to be subsiding in a satisfactory manner (the temperature is rarely subnormal). (2) The frequency with which this reaction is accompanied by sore throat and vague and indefinitely localized discomfort or pain over the chest.

As it is unsafe to give another injection of gas whilst a reaction of this type is in progress, the pneumothorax method of treatment may have to be abandoned because during the intervals the lung re-expands and becomes adherent. It may, however, be possible to avoid this catastrophe if streptococcal vaccines are given concurrently with the pneumothorax treatment

The best results are obtained, of course, in those cases in which complete collapse of the lung is possible owing to freedom of the pleural cavity from all adhesions (the lung not being solid by pneumonic consolidation or too rigid by intense fibrosis), and in which the mediastinum is not too mobile.

Adhesions may entirely prevent this form of treatment, or they may allow of a partial collapse only. If sufficient gas can be introduced to form a pocket equal to about one-third of the pleural cavity, especially if it is over the area of lung which is most diseased (this is essential when the pneumothorax has been undertaken for the treatment of a cavity), and such pocket can be maintained, the *result*

will eventually be beneficial, but the immediate improvement in the symptoms will not be so pronounced as in cases of total collapse.

Pneumonic consolidation, as in the acute forms of pneumonic tuberculosis, may delay the production of complete collapse for several weeks. The treatment should, however, be persisted with, as resolution will take place, at first gradually and then, possibly, rapidly.

The interference with complete collapse by intense fibrosis is not so serious a matter; but if, in addition, there is a mobile mediastinum, the degree of pressure exerted on the lung will have to be modified so as to avoid too extensive displacement of this central partition. This might, if very excessive, be accompanied by too severe a compression of the opposite lung, and even by obstruction (due to pressure or kinking) of the bronchus to that lung Such a condition of affairs is quite unjustifiable, and can always be avoided if control by X-rays is used.

Indications.—If there is definite disease in one or more lobes of a lung, and no contra-indication, then artificial pneumothorax should be induced. It is particularly valuable·

(A) When there is—
- (1) Cavity formation.
- (2) Secondary infection.
- (3) Repeated or long-continued hæmoptysis.
- (4) Progress of the disease despite medical treatment.
- (5) Associated laryngeal tuberculosis.

(B) As a means of—
- (1) Definitely prolonging the life of a young adult.
- (2) Enabling a mother to return to her children with less risk of infecting them.
- (3) Enabling the working man to return to work or to an unsuitable environment.

The **contra-indications** are—
- (1) The absence of sufficient healthy lung tissue in the opposite side to carry on the functions of respiration.
- (2) The presence of cavities or of retention of secretions in the opposite lung.
- (3) The presence of albumin or sugar in the urine, or of abdominal tuberculosis.
- (4) Excessive intestinal stasis.
- (5) Extreme nervousness of the patient.

Technique.—The essentials of the apparatus required are a hollow needle connected, by way of a filter, with the graduated cylinder containing the gas and with a water manometer (Fig 724). It is advisable to have two cylinders, a small one containing oxygen and a large one

containing nitrogen. The gas is displaced by allowing water to enter the cylinder at the bottom, driving the gas out at the top; the rate of flow should be under absolute control. The track of the needle through the chest wall should be anæsthetized with 2-per-cent. novocain to prevent a pleural reflex (*see* p. 379). The needle is passed through the 5th, 6th, or 7th intercostal space in the mid- or the anterior axillary line.

When the needle enters the pleural cavity the fluid in the manometer will show a negative pressure and will oscillate with each respira- Until gas actually has been nto the pleural cavity, the metric movements may be so t as to be doubtful. It is efore safer to run in oxygen ead of nitrogen until the movements clearly indicate that the tal opening in the needle is iere required, otherwise there is e danger of gas embolism (*see* . 379).

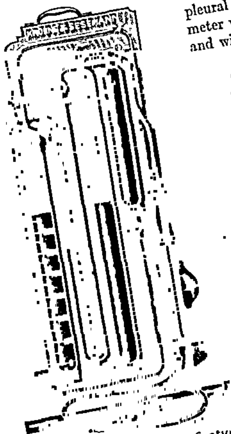


Fig. 724.—Author's modification of Kornmann's apparatus for introducing gases into the pleural cavity (nitrogen displacement or oxygen replacement).

If no adhesions are present, the nanometer will show, as the gas enters, very gradual diminution only of the negative pressure. If, however, the needle has entered a space which is closed off by adhesions, the pressure will undergo a rapid change from negative to positive, the respiratory undulations will decrease, and the patient will complain of pain, or of a feeling of intense oppression, and of difficulty in breathing. Under these conditions it will be necessary to stop the flow of nitrogen, and the surgeon will probably be obliged to abandon the artificial pneumothorax.

In a straightforward case the first dose should not exceed 250 c.c., lest too big a reaction be produced (unless the treatment is for the arrest of a continuous and serious hæmorrhage, when the flow of gas must be continued until the hæmorrhage stops). At each successive injection—every second or third day until the lung is collapsed to the



Fig. 1.—Collapse of lung by artificial pneumothorax interfered with by adhesions.



Fig. 2.—Same case as Fig. 1, after division of adhesions by author's method.

PLATE 121.

Fig. 1 —Collapse of lung by artificial pneumothorax interfered with by adhesions

Fig 2 —Same case as Fig 1 after division of adhesions by author's method.

PLATE 122.

maximum possible (unless a reaction demands a longer interval)—the amount of gas can be increased by 150 c.c. Once the lung is as fully compressed as possible, the intervals between the injections are to be rapidly increased. In an average case a monthly interval will be reached four months after the beginning of the treatment; this can be lengthened later according as the rate of absorption is found to allow.

In a case free of adhesions the negative pressure will not be changed to positive by the gas until a total of about 2,000 c.c. has been given. A maximum positive pressure equal to 5 mm. Hg is usually sufficient to obtain the required collapse and compression. When adhesions are present, much higher pressures may be necessary in the endeavour to separate the lung from the chest wall or to stretch the adhesions. The greatest care, however, is necessary in such cases, and constant examination with the X-rays is imperative.

Complications. 1. *Pleural syncope.*—This is a reflex which may be produced at the moment of puncture of the pleura. It may be quite mild, causing syncope only, but it may be extremely severe, resulting in almost instantaneous death.

2. *Gas embolism.*—This is due to the introduction of air or nitrogen into a vein of the lung. The embolus may be large enough to cause death, or less severe, resulting in hemiplegia or monoplegia.

3. *Pleural effusion.*—This, the commonest complication, is probably due to—(1) Irritation of the pleura, especially when traction is made on adhesions. (2) Mild degrees of infection. (3) B. coli toxæmia. (4) Infection by tubercle bacilli. The fluid may be rapidly absorbed or may be very persistent. In the latter case it is advisable to try aspiration combined with washing out of the cavity with oxygen; in such cases it will be necessary, a few days later, to refill with nitrogen to make up for the oxygen absorbed.

4. A *spontaneous pneumothorax* due to the lung being torn at the point at which an adhesion is attached.

Results.—The abolition of symptoms in unilateral uncomplicated cases has already been mentioned. After the initial injections, however, there is always an increase of sputum and of the cough necessary to clear the bronchial tubes of this secretion. As a refill becomes due there is generally some return of or increase in symptoms due to the lung re-expanding. Most noticeable, in some cases, is the increase in the dyspnœa, which will again disappear the moment the lung is re-collapsed.

Treatment of isolated adhesions.—The finest adhesions can be ruptured. Some will stretch if continuous tension is kept on them. Bands which will not yield beyond a certain length and which interfere with the collapse can be divided by a tenotome (Plates 121, 122),

X-rays being used to view the adhesion while cutting it, or the adhesion can be burnt through with a galvano-cautery, a thoracoscope being passed through the chest wall so that the surgeon may view the adhesion and control the operation (p. 387).

Bilateral pneumothorax.—This is indicated (1) if the disease in the second lung begins to progress while the first is under treatment; (2) if there is active disease on both sides which progresses *despite* medical treatment, but the general and cardiac conditions are good. Artificial pneumothorax should be started *on the one side and the lung collapsed to half its size.* If the patient shows definite improvement, the second lung *may be partially collapsed. Not more than 1,000 c.c.* of gas should be kept in on either side. (Plate 120, Fig. 2.)

Extrapleural compression of the lung.—When artificial pneumothorax is impossible, compression of the lung by extrapleural methods may be indicated. Much greater caution is necessary in the selection of the cases suitable for this treatment. Active disease elsewhere, or the presence of old disease in the opposite lung unless limited to the hilum, is an absolute contra-indication.

Extrapleural collapse *of the whole lung* can be produced by (1) decostalization, (2) Wilms' operation of rib mobilization; *of the apex,* by replacement by foreign bodies; *of the base,* by paralysing the diaphragm with or without local rib resection.[1]

When the disease is localized to the upper part of the upper lobe, or to the whole of it even on the right, the local operation should be done in preference to the general, as the former is much less severe. In some cases where disease has spread on the same side beyond the upper lobe, but is then quiescent, and there is active trouble in the upper lobe only, especially if there is a cavity there, it may be advisable to cause local instead of general collapse, if the condition of the patient is not favourable for the latter.

Wilms' operation, which consists in removing lengths from the posterior ends of the first ten ribs and of all the costal cartilages from the first to the seventh inclusive, has to be done in two stages, and is *incomplete unless the first rib* and the costal margin are efficiently dealt with. The former is the difficult part of the operation. It is *more severe than the operation of decostalization,* for the success of which the removal of the first rib is not so essential.

In *the local collapse operation* for the upper lobe, the treatment consists in displacing the upper lobe either by paraffin or by fat or other mass of tissue (*for details see* p. 388). Fat may not be obtainable from the patient; precautions are required if tissue from another person be used. *The objection to paraffin* is that it is liable to produce a serous exudate. This exudate may interfere with the healing of

[1] *The operations are described at* p. 387.

the wound and may cause the escape of the paraffin; secondary infection may then occur.

Section of the phrenic nerve in order to paralyse one half of the diaphragm is not of much value by itself in the treatment of tuberculosis. It may, however, be necessary for the relief of symptoms. In some cases of chronic tuberculosis with extensive fibrosis of the left lung, the base of this organ, having become adherent to the diaphragm, drags it up with it as the lung shrinks. Vomiting is a constant feature of some of the left-sided cases, and interferes with the improvement of the patient's health. It can be abolished if the diaphragm on that side is put out of action.

This operation is particularly valuable also in those cases in which *adhesions to the diaphragm interfere with collapse of the lung* by artificial pneumothorax, the pull on the diaphragm, so long as a positive intrapleural pressure is maintained, causing an extremely distressing dry cough with every exertion

STREPTOTRICHOSIS

The clinical picture of pulmonary streptotrichosis closely resembles that of chronic bronchitis or of tuberculosis, and the condition can only be recognized by a careful examination of the sputum. The streptothrix may be the primary cause of the disease, it may be associated with tuberculosis, and it is not infrequently found in cases of bronchiectasis.

Occasionally the course of the disease is rapid, especially when the fungus is actinomyces. Karewski divides the clinical progress into three stages:

1. Insidious onset, during which slight cough accompanied by a little expectoration is for some time the only manifestation; later, signs indicative of a localized infiltration at the base, or suggestive of tuberculosis at the apex, are present. As the consolidation breaks down there is hæmoptysis, the blood, unlike that in tuberculosis, being intimately mixed with the sputum.

2. There is involvement of the pleura, and recurring effusions are followed by a dense adhesive pleurisy. The disease invades the chest wall, attacking ribs and soft parts indifferently. Pain is pronounced, the patient becomes definitely ill, there are fever, dyspnœa, and an obvious inflammatory swelling The chest wall is motionless and retracted as a result of a fibrous shrinking of the lung; for the same reason there may be displacement of the heart. The sputum is more abundant, and may contain yellow granules.

3. The swelling breaks down and discharges through several sinuses. As a result of the erosion of vessels, pyæmia may be the termination.

The radiographic appearance is either that of chronic fibrosis of the lung, of a diffuse infiltration along the bronchi and bronchioles, or of

a dense, ill-defined shadow spreading from the lung to the adjacent structures.

Treatment.—In the early stages *vaccines and internal administration* of potassium iodide in large doses must be tried. If the disease *is confined to one lobe*, and progresses despite this treatment, pneumectomy is the only certain means of cure. Even when the fungus is involving the pleura and the chest wall, extensive and repeated excision of the infected tissues will produce temporary improvement, and possibly even permanent benefit.

SYPHILIS

Syphilis of the lung does not need surgical intervention, but, inasmuch as it is generally mistaken for tuberculosis, attention must be drawn to the means of differentiating between the two conditions.

Syphilis is essentially a disease which produces symptoms far in excess of physical signs. Within a few months of the onset the general condition of the patient resembles that of an advanced case of pulmonary tuberculosis, while the physical signs are suggestive rather of an early stage of the same disease, or of scattered patches of bronchopneumonia.

The radiographic picture is either that of a localized uniform shadow due to a gumma (Plate 123) or of fibrosis of the lung. In any case in which there is the least suspicion a Wassermann test should be done.

HYDATID CYSTS OF THE *LUNG AND PLEURA*

Pathology and etiology.—Undoubtedly the great majority of these cysts are the result of the ingestion of the ova of *Tænia echinococcus, the digestion of the capsule*, and the *liberation of the embryo*, which, burrowing through the stomach wall, enters a vein of the systemic *or of the portal circulation, and reaches the lung by the* pulmonary artery. But it is also possible that some of the cases are the result of direct inhalation of the ova. The parasite may develop in young children or in adults.

Morbid anatomy.—The lung, next to the liver, is the organ most often invaded by this parasite; the lower lobe on the right side is more frequently attacked than the others. The embryo as it develops *loses its hooklets* and forms a cyst lined with an external translucent laminated ectocyst and an internal granular endocyst from which the *brood-capsules develop*. The fluid within these walls is normally clear, slightly saline, and non-albuminous.

The cysts *may be filled with brood-capsules, scoleces, and daughter-cysts*, or may be sterile and contain fluid only.

The hydatid in its growth produces *displacement and erosion* of the neighbouring structures, but in the lung it does not excite the



Gumma of lung.

PLATE 123.



Fig 1—Hydatid of right lung



Fig 2—Squamous carcinoma of the right lower lobe The growth was completely removed by excising the lower lobe It was adherent at one spot only to the parietal pleura on the postero-external aspect

PLATE 124.

formation of a secondary fibrous capsule. Hydatid cysts of the lung are, as a rule, solitary: both lungs may be affected, or the lung together with some other organ. Secondary implantation cysts from rupture of the primary cyst are very rare.

Symptoms and physical signs.—With the growth and later probable rupture or suppuration of the cyst the symptoms and signs change considerably. According to Escudero, it takes two years for the embryo to manifest itself clinically.

Hæmoptysis is frequent, but the blood is rarely more than sufficient to tinge the sputum. The cough when present is hard and frequent or paroxysmal; pain is absent unless the pleura is involved. Pyrexia independently of suppuration is sometimes seen. Urticaria is an occasional symptom. The physical signs are those of a well-localized tumour: there may be some fullness of the chest and some alteration in position of the heart's apex; there is a well-defined area exhibiting dullness, diminution or absence of breath-sounds, and loss of vocal fremitus; around this there is usually a zone over which tubular breathing and râles can be heard. Very occasionally the cyst bulges through an intercostal space, forming a rounded subcutaneous tumour; in these cases only is a thrill obtainable. If the cyst is deeply situated it may be symptomless, and the signs those of a localized patch of compressed lung only.

With increase in size, rupture may occur into the pleura, pericar-

[illegible]

Pain and dyspnœa are intense, and the distress of the patient is extreme. Death often occurs from suffocation. Severe hæmorrhage may be present from simultaneous ulceration into a large vessel. Occasionally the cyst ruptures into both pleura and bronchus, and a pneumothorax or pyopneumothorax is superadded. Sometimes the rupture is more gradual, and then the symptoms are less intense. Rarely such evacuation is followed by cure, or the cyst refills and the contents are again discharged, producing the same distressing phenomena. Usually the hydatid becomes infected, and the symptoms and signs of a suppurating cavity appear (*see* Abscess, p. 367).

Diagnosis.—The differential diagnosis of hydatid of the lung and of the pleura is often difficult. Deep-seated cysts are tolerated better than superficial ones or than hydatids of the pleura. Those coming in contact with the pleura or pericardium cause an inflammatory reaction which manifests itself by the presence of pain and friction sounds.

Radiology is of the greatest importance in the diagnosis of hydatids. When the cyst is filled with fluid it appears as a dark, more or less

round, homogeneous shadow with a sharply defined outline (Plate 121, Fig. 1).

In a cyst which has ruptured, the shadow varies with the amount of fluid contained. If empty, the appearance of a ring with a clear centre is obtained. When the cyst is only partially filled with liquid there is the well-defined convex lower border of the hydatid, the upper limit of the liquid is a horizontal line, and above this is the less distinct shadow of the collapsed part of the hydatid. During the process of healing the contraction of the cyst wall produces an irregular shadow.

Accessory factors assisting in confirming the diagnosis of hydatids are the presence of eosinophilia (although this is by no means constant); the appearance of a precipitate by the addition of hydatid fluid to the patient's serum (this is confirmatory evidence only when a positive result obtains); and the presence of antibodies, which are found in 95 per cent. of cases of active hydatid disease and in 60 per cent. of patients who have previously been affected.

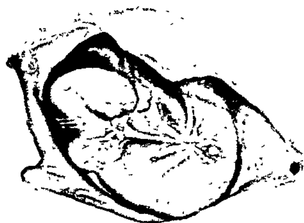
Prognosis.—Spontaneous cure may occur, but is very rare. Cure after a rupture into a bronchus is more common, especially in children. The statistics collected by Guinbellot show that the mortality of 391 cases treated medically was approximately 55 per cent., as compared with 229 cases treated by thoracotomy with a mortality of 18.5 per cent. when suppuration had occurred before operation, and a mortality of 8 per cent. only in the uninfected cases.

Treatment.—Aspiration must on no account be done, as the mortality of the procedure is over 60 per cent. For hydatids of the lung the operation of thoracotomy and pneumotomy (p. 389), with free opening of the cyst, affords the patient the best possibility of cure.

Exploratory puncture is permissible after the pleura has been widely exposed and the two layers, if not already united by adhesions, sutured. This procedure is, however, at times followed by immediate rupture of the cyst into a bronchus; should this happen, a wide opening must be made into the hydatid to prevent the patient being drowned by the contents.

[illegible] be emptied of its [illegible] d then treated as [illegible] free incision the endocyst is stripped off and removed; it is not safe to remove the ectocyst owing to the excessive bleeding produced thereby. Since, however, the ectocyst prevents collapse of the walls, the margins of the cavity are sutured to the muscles of the thoracic wound, and a large drainage-tube is introduced.

The treatment of hydatids of the pleura is the same, except that pneumotomy is not required, and instead of suturing the pleural



Dermoid of the mediastinum.
(*Author's case*)

PLATE 125.

membranes together the parietal pleura is carefully sutured to the wall of the cyst before opening the latter.

The complications of operative treatment of hydatids are:

1. Rupture of the cyst into a bronchus during the operation.
2. Hæmorrhage from the wall of the cyst, which may be fatal.
3. Pneumothorax and pyothorax.
4. Urticaria due to intoxication from the contents of the cyst; when this occurs, the symptoms appear from five to seven days after the operation, and last from a few hours to even three weeks.
5. Infection of the cyst after it has been opened.
6. A broncho-cutaneous fistula. If this occurs and persists, attempts must be made to close it by excising a cone-shaped area of skin and lung tissue, suturing the exposed lung as completely as possible, and then the skin.

TUMOURS

Simple Tumours

Benign tumours, such as fibroma, enchondroma, lipoma, are almost always symptomless. Dermoids and teratomas originate in the mediastinum (Plate 125), but they involve the lung, and in the course of time open into a bronchus, when their presence can be recognized by the sebaceous matter or hairs found in the expectoration; or they become infected and form an abscess which bulges through an intercostal space. Dermoids usually manifest themselves about the age of puberty, and produce symptoms of pressure on the lung and of displacement of the heart.

Malignant Tumours

Pathology.—Primary carcinoma of the lung originates from the bronchial epithelium, when it is squamous in character; less commonly as a columnar growth starting in the bronchial glands. Primary sarcoma is very rare.

Symptoms.—A constant irritating cough with, at first, little sputum; later there is mucopurulent expectoration which may be blood-stained or "prune-juice" in appearance. In the sputum the characteristic large cells with fat granules and the epithelial cells with tail-like processes can generally be found. Pain is present when the parietal pleura is invaded, and may then be local or referred. With increase in size of the growth there is evidence of pressure on the surrounding organs.

The symptoms, however, may for a considerable period be those of chronic bronchitis only.

Physical signs may be absent, may be those of chronic bronchitis, of pressure on a bronchus, or of an area of consolidation. The signs may be masked by a pleural effusion.

Radiology.—A primary neoplasm gives a dense, but not necessarily uniform, shadow with a well-defined margin. The adjacent lung tissue shows no pneumonic change such as is seen in the neighbourhood of an inflammatory focus. If the lung is obscured by fluid, the latter must be drawn off by the oxygen-replacement method.

Treatment.—The only hope of cure rests in early diagnosis while the tumour is localized to one lobe, and before the glands at the hilum are invaded. The lobe involved must in these circumstances be amputated (*see* p. 389). (Plate 124, Fig. 2.)

BRONCHITIS AND EMPHYSEMA

Some patients who suffer from chronic bronchitis and emphysema are found to have a rigid and dilated condition of the chest. Freund, who first described this association in 1858, considers that the rigid dilated thorax is due to ossification processes in the costal cartilages of the 2nd to the 5th ribs, which gradually cause the thorax to assume the position of extreme inspiration, thereby preventing respiratory changes in size, and that as a consequence bronchitis and emphysema develop.

The coexistence of bronchitis and emphysema and of a rigid dilated ... be greatly benefited by ... rs ... of ... It ... the

As yet our knowledge is not sufficient to ... een ... treatment and those that ... an absolutely ... often derive ... omy. This is ... t heart. The ... r in the lungs

Treatment.—Medical treatment is ... ks. Rest in bed and a course of *injections* with an autogenous vaccine are advisable as preliminary steps to operation.

The operation is done under regional anæsthesia. A vertical *incision* is made, 2 ... right border of the sternum, from the 1st to the 6th ... muscles

cartilages ...

are dissec ...

aspect. ...

intercostal nerves should be injected ...

the after-pain. This is particularly *important*, as otherwise the patient

remarkable.

OPERATIVE PROCEDURES

Section of the phrenic nerve.—This nerve is divided in the neck by an incision along the posterior border of the sterno-mastoid muscle. The edge of the muscle is defined and retracted mesially. After division of the deep layer of fascia and displacement of the glands and vessels overlying the scalenus anticus muscle, the nerve will be exposed lying on the anterior surface of that muscle. It is divided, and the two ends are left in apposition.

Division of adhesions. (1) By tenotome (author's method).—It is essential that a clear view of the band be obtained with the X-rays. The patient is placed in front of the X-ray tube; the tissues of the intercostal space immediately overlying the adhesion are anæsthetized with 2-per-cent. novocain; the special tenotome is passed through the chest wall till the blade is inside the pleural cavity, the room is darkened and the X-rays are switched on. The tenotome is then moved up to the adhesion until it meets it and rests on it. The band can now be cut through by sawing movements. As soon as the adhesion is divided the lung will be seen to collapse towards the mediastinum.

(2) By cautery (Jacobœus's method).—Jacobœus passes a thoracoscope through an intercostal space close to the adhesion. Through an adjacent space he passes a cannula, and through this an electric cautery. By means of the thoracoscope the cautery is guided up to the adhesion, which is then divided

Rib resection.—The most convenient incision for extensive rib removal in children is one made just in front of the midaxillary line from the apex of the axilla downwards as far as is required. This will give access to all the ribs except the last two. The edges of the wound are retracted, and the ribs exposed The periosteum is divided and freed from both surfaces of the visible portion of bone It is then freed from the anterior and posterior portion of ribs by Doyen's periosteal elevator, in front as far as

portion is bent backwards, and may snap at the angle If the rib is too carious for this procedure, curved bone-forceps must be slid along the bone, which is divided at the angle. The wound is then closed, a small drain being left in for twenty-four hours.

In adults this incision does not give sufficient access to the posterior parts of the ribs, the removal of which is of even more importance than the anterior. The incision therefore should be made parallel to the vertebral border of the

the scapula are cut the arm is drawn forwards and upwards by an assistant and, the scapula being carried with it, a clear view of the field of operation is obtained.

The ribs are stripped along the entire length of the periosteum and divided at the angle. In order more easily and expeditiously to divide the anterior *end of the ribs, which is out of sight*, the author has had his bone-forceps made with a metal ring fixed to the posterior surface of one blade. The cut end of rib is slipped through this ring, which guides the blades to the point of section.

It is advisable to start with the resection of the 5th or 6th rib and to work upwards to the 1st, of which not much more than 2 cm. can be removed with safety. If the patient's condition does not warrant further measures at this stage, the remaining resection can be postponed.

Both these operations and that of rib mobilization can be done under regional anæsthesia. In the author's opinion, chloroform is preferable, as the mental strain to the patient is tremendous In addition, as a preliminary to the incision, the intercostal nerves should be injected each with 5 minims of absolute alcohol at a point close to their exit from the foramina. This makes an immense difference to the amount of shock and after-pain.

In cases of chronic empyema, after the bony framework has been removed, the intercostal muscles, periosteum, and parietal pleura overlying the cavity should be cut away before suturing the skin incision.

Rib mobilization.—This operation is done in two stages *At the first*, from 3 to 8 cm. of the posterior parts of the first nine or ten ribs are cut away, access being obtained through a vertical incision lateral to the outer border of the erector spinæ muscles. The second stage is done as soon as the patient has recovered from the first, and before the posterior ends of the ribs have become fixed by scar tissue (within six weeks at latest). In this operation the costal cartilages from the first, down to and including a wide part of the costal margin, are removed. The ribs are now freed from their attachments both in front and behind; consequently they drop downwards *en masse* with the intercostal muscles; the cut ends become approximated to the middle line, and the ribs tilt downwards ("bucket-handle action"). These three movements cause great diminution in the size of the pleural cavity, and consequently great and permanent collapse of the lung.

Mobilization of the first rib is an essential part of the operation, as on the free movement of this depends the free and efficient falling down and in of the rest of the chest wall. But division of the first rib is very difficult, and *great care is required to avoid injury* to the dorsal nerve in the posterior operation and to the subclavian vein in the anterior operation This operation is more serious than that of resection.

Local displacement of the lung.—*The lung, by this method of* treatment, is displaced together with the visceral and parietal pleural mem- [illegible] for those cases in [illegible] *is made over* [illegible] id intercostal [illegible] is stripped off [illegible] *rried out* with [illegible] or and apical [illegible] apsed against [illegible] ll. *Into* this is inserted a lump of fat (preferably [illegible] 's buttock or

abdominal wall), a mass of omentum, a lipoma, or a fibroid. The wound is closed over this without drainage.

Paraffin with a melting-point of 112° F. can be used instead of the above tissues. The disadvantages of this have been pointed out on p. 380.

Thoracotomy.—When it is desired to operate in the region of the hilum of the lung, the most satisfactory access is obtained by making an incision along the 6th intercostal space, extending in front as far as the

portions usually of three ribs, is the most suitable. The sides of the flap should be parallel to the ribs. The flap is reflected in two layers, the first consisting of skin and superficial muscles, and the second of the ribs and intercostal muscles. If a partial collapse of the chest wall is desired, the ribs can be excised before reflecting the second flap.

Before exploring the lung in cases of abscess the two layers of the pleura must be united round the line of the incision. This union, if not already accomplished by the disease, may be effected either by packing gauze on the surface of the parietal pleura a few days prior to the pneumotomy, or preferably by stitching the membranes together with a continuous circular suture, each loop of thread overlapping the previous one. It is advisable to include lung parenchyma with the visceral pleura to prevent the stitches cutting out.

Pneumotomy.—The lung is divided either by the cautery or by the knife. The cautery checks the bleeding from the smaller vessels only, chars the surface, and obscures the anatomy of the part. When the parenchyma is divided with the knife, and with a blunt dissector in the deeper parts, the larger vessels can be seen and ligatured before section. The incision should be along the whole length of the exposed united pleura: a wider view into the lung can be obtained by a crucial incision.

To check the bleeding at the end of the operation the whole wound is packed with gauze.

Pneumectomy.—Amputation of the whole lung or of one lobe is done either by clamping the root, reflecting flaps of visceral pleura, dividing and ligaturing the vessels, and then stitching the flaps over the raw surface; or by blunt dissection exposing the vessels and bronchus, and ligaturing them separately before cutting them

The bronchus must be crushed and ligatured, the cut end invaginated, and

cov

of t

pleura through an opening made by reflecting an osteoplastic flap containing portions of the dorsal ends of the 5th, 6th, 7th, and 8th ribs.

After it has given off its first branch the bronchus is accessible by intrapleural operation only.

The bronchus is opened longitudinally. Closure is effected by a series of sutures passing through the outer coats only, excluding the cartilages.

The first and last sutures are left long to tie round a cone of lung tissue which is drawn down over the line of sutures.

Ligature of the branch of the pulmonary artery supplying the lower lobe (Sauerbruch).—*Any adhesions between* the lower and upper (and middle) lobes are carefully divided, and the upper lobes reflected upwards and inwards. The lower lobe is seized with the hand and the bronchus located. Blunt dissection immediately above and external [illegible]

[illegible] before it has healed, or before the union is strong enough to resist the increase in the intrapleural pressure, the liquid must *be aspirated and replaced by* oxygen, as there is the danger otherwise that the liquid will *force its way through the wound, form a sinus, and eventually lead to infection of the* pleural cavity.

Trendelenburg's operation for removal of clot from the pulmonary artery.—A horizontal incision is made *along the upper border of the 2nd costal cartilage and rib on the left side* for a distance of 10 cm.; a second incision is made at right angles to this *along the left sternal border from near the top of the manubrium sterni to* the 3rd costo-sternal junction. The flaps, consisting of the soft parts, are reflected upwards and downwards. The costal cartilage and the exposed [illegible] the cartilage of the 3rd rib is divided. [illegible] cm from the costal margin, and the [illegible]ricardium is slit from below upwards internally to the phrenic nerve. A curved blunt sound is passed round the aorta and pulmonary artery through the transverse pericardial sinus; a rubber tube is fixed to the sound, [illegible] the tube surrounding the vessels. The ve[illegible] rubber tube up to the sternum. [illegible] *ally on the outer side for* ¾ cm [illegible] is removed. The edges of the artery [illegible] compressing [illegible] the clot, and [illegible] release the artery must not be more than [illegible] The artery is sutured with the clamp *in situ*.

In no case, as yet, has the operation been entirely successful.

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INJURIES AND DISEASES OF NERVES

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NERVE INJURIES

Classification.—Nerve injuries may be classified as follows:—

Complete division ..	Anatomical. Continuity interrupted. Physiological. Conduction interrupted, but naked-eye continuity intact.
Incomplete division ..	Anatomical. Physiological.

Methods of production. — Every nerve injury may be referred to one of three causes: (1) a wound, accidental or operative; (2) pressure; (3) traction.

Accidental **wounds** of the median, ulnar, or radial nerves near the wrist are common in civil life. The operative division of small cutaneous nerves is of little importance; sensory restoration follows accurate coaptation of the wound edges and healing by first intention.

The nerves most often injured during operations are the branches of the cervical plexus, the spinal accessory, the facial, and the musculo-spiral nerves. Next in frequency come the nerves of the abdominal wall; incisions in the linea semilunaris may divide the lower dorsal nerves supplying the [illegible]

of hernia.

Pressure on nerves.—The pressure may be either momentary or long-continued

The musculo-spiral nerve suffers most frequently (*see* p 418); less often the brachial plexus is compressed by the dislocated head of the humerus or by the heel in attempts at reduction [illegible]
lence producing a frac [illegible]
The median and ulna [illegible]
and suffer in over half the cases of Volkmann's ischæmic contracture of the forearm muscles. The pressure of the strapping used in Sayre's treatment of fracture of the clavicle is occasionally responsible for injury to the ulnar nerve.

Traction injuries.—The brachial plexus [illegible]
T [illegible]
d [illegible]
h [illegible]
with or without a fracture of the radius.

The overstretching may result in anatomical or physiological division, which may be complete or incomplete. Physiological is more common than *anatomical*, and incomplete than complete division.

Nerve injury complicating fracture may be primary, at the moment of fracture, either *due (a) to the fracture itself* or (*b*) to the etiological violence, e.g. a fall on the point of the shoulder may cause both fracture of the clavicle and traction injury of the brachial plexus. More commonly it is secondary, and due to involvement in callus or to pressure by the displaced end of the bone

The nerve may be ruptured, lacerated, contused, or compressed between the ends of the bone. In most cases the symptoms result from pressure and cause weakness or paralysis of muscles, accompanied by more or less loss of sensibility. Occasionally, when the nerve is lacerated, pain may arise in its distribution a few days after the injury.

Interference with nerve functions may arise many years after the fracture, as in the late involvement of the ulnar nerve after fractures in the region of the elbow-joint (*see* p. 422).

In both primary and secondary injuries the division is more often incomplete than complete, and, even in the primary form, more frequently physiological than anatomical.

The musculo-spiral nerve suffers most often in the upper limb, the external popliteal in the lower.[1]

Nerve injury complicating dislocations, if primary, results from direct pressure by the head of the bone at the moment of dislocation from attempts at reduction, or from the initial violence.

Secondary involvement occurs only in unreduced dislocations, and is *due* [illegible] *of the bone, or to inflam-*
mat[illegible]

[illegible] of subcoracoid dislocation of the humerus, the brachial plexus, especially its inner cord, being injured. In subglenoid dislocations the circumflex or musculo-spiral nerve may *suffer*. The *ulnar nerve is sometimes injured in dislocations* of the elbow, the posterior interosseous in forward dislocations of the head of the radius, and the great sciatic or obturator nerve in dislocations of the hip.

[illegible] *usually* [illegible]

Postural injuries may be due to direct pressure, as [illegible] on the musculo-spiral, or by a Clover's crutch or an Esmarch's bandage on the external popliteal nerve; or they may follow traction, as when the arm is strongly abducted or raised above the head. In the latter case the right brachial *plexus, especially the 5th cervical nerve*, suffers most often; it is never thus damaged when the arms are kept to the side.

The division is usually "incomplete physiological," and the majority recover without active surgical interference. In all that have come *under* my notice, spontaneous recovery occurred.

Gunshot wounds of nerves *may* cause complete or incomplete anatomical or physiological division. The latter may be primary or secondary from later involvement in fibrous tissue or callus. In some instances the signs of complete division develop later from the resulting *fibrosis, and*

[1] My experience agrees with that of Bruns, who in collected cases found the order of frequency to be as follows: Out of 189 cases, 77 musculo-spiral, 25 external popliteal, 19 ulnar, and 17 median.

indicate operative treatment. In other cases pain and tenderness occur (causalgia), rendering neurectomy necessary. The nerves most often injured, in order of frequency, have been the ulnar, median, musculo-spiral, and the sciatic or its external popliteal division.

Symptoms following complete division of a nerve.

Changes in sensibility.—Complete division of a mixed or sensory nerve causes a well-defined loss of sensibility to light touch, and an ill-defined and smaller area of loss of sensibility to prick, which varies within wide limits, sometimes being almost as extensive as the loss of sensibility to light touch, at others falling far short of it. Sensibility to deep touch may be lost if the nerve has been divided above all its motor branches, or if tendons have also been severed, but is rarely affected so extensively as sensibility to prick.

The loss of sensibility present immediately after the injury remains unchanged until regeneration of the peripheral end and reunion with the central nervous system.

The afferent fibres in a peripheral nerve may be divided into three groups (Head and Sherren):

1. *Deep sensibility*.—These conduct impulses produced by pressure; its gradual increase and the pain induced by excessive pressure can be appreciated. Through this system are recognized the extent and direction of the movements of joints and muscles. The fibres run mainly with the motor nerves, have widespread anastomoses, and are not destroyed by division of all the sensory nerves to the skin

2. *Protopathic*, through which painful cutaneous stimulation and extreme degrees of temperature are recognized.

3. *Epicritic*.—This group responds to light touches with a well-localized sensation. Through it minor degrees of temperature are differentiated and two points discriminated.

Division of peripheral nerves without sensory change.—Certain nerves can be divided without producing sensory change appreciable by any present methods of testing. These are the musculo-spiral below the origin of its external cutaneous branches, the radial nerve in the upper two-thirds of the forearm, and certain of the anterior primary divisions of the cervical nerves which enter into the formation of the brachial plexus and single posterior roots.

Division of posterior roots.—Division of several roots produces an area of loss of protopathic sensibility larger than that of loss of light touch.

Intradural division of posterior roots is occasionally necessary for severe pain due to ascending neuritis following nerve wounds or amputation neuromas. The results have been by no means always successful.

Similarly, it has been carried out for the relief of gastric crises of tabes (7th–9th dorsal) and for spastic paralysis (Förster's operation).

Motor symptoms.—Complete division of a motor nerve causes immediate paralysis of the muscles supplied by it.

The paralysed muscles atrophy and may become converted into a mass of fibro-fatty material devoid of all contractile power.

Unless precautions are taken they will be *overstretched* by the action of the opposing muscles, and these latter become permanently contracted.

After division of its motor nerve a muscle ceases to respond to stimulation with the interrupted current in from four to seven days. At about the tenth day[1] the muscles respond to the stimulation of the constant current with a sluggish, wave-like contraction, and a stronger current must be used to call it forth than on the sound side. The contraction appears first at the closing of the circuit, when the anode is used as the testing electrode (A.C.C.>K.C.C.). To these phenomena the term "reaction of degeneration" (R.D.) is applied.

The condenser discharge method cannot take the place of tests with the faradic and galvanic currents, which are the important ones from the surgical point of view.

Changes in the skin.—The superficial layers of epithelium no longer desquamate so readily over the area of loss of sensibility to prick. After desquamation has taken place the skin is wrinkled, pinkish-blue in colour, colder than normal, and dry. *A prick bleeds* more readily than elsewhere and leaves a red spot or papule, which may persist for many hours, or even days.

During the time that the skin is insensitive to protopathic stimuli it is peculiarly liable to injury leading to the formation of "trophic" ulcers. These originate in blisters, produced in many instances by injuries so slight that no damage results to the neighbouring sound skin. The ulcers heal readily if kept at rest and free from irritation, and remain localized to the analgesic portion unless they become infected.

The nails are altered in texture and lose their gloss. They become more highly curved than normal, and ribbed in both the transverse and longitudinal directions, and often show a heaping-up of epithelium under their free edges. Their rate of growth may be slow; this is due to want of movement.

Changes in bones and joints.—Arthritis seldom results from nerve injury, but changes take place in the ligaments of joints re-

[illegible] after separation from their anterior horn cells that the [illegible]

tained in an abnormal position. Fibrous ankylosis may occur, but is unusual. Changes in the bones are uncommon.

Symptoms following incomplete division.—"Incomplete division" implies interruption or impairment of conductivity without degeneration of the whole peripheral end. It may be (*a*) anatomical, due to a wound or partial rupture, or (*b*) physiological, the result of compression of the nerve by fibrous tissue, extrinsic or intrinsic, by bone, blood-clot, growth, or external violence.

The teaching that incomplete injuries of nerves affect motor more than sensory fibres has been shown by the writer to be erroneous. Motion is affected alone, or to a greater extent than sensation, only when the injury affects nerves such as the musculo-spiral or the 5th cervical anterior primary division, the complete division of which has no demonstrable effect upon sensation

Sensory symptoms.—The slightest sensory change is almost entirely subjective; the patient is conscious of an area of skin altered in sensibility, usually demonstrable by the changed sensibility produced at its borders when cotton-wool is dragged lightly across the skin from sound to affected portions (line of change), but there is no loss of sensibility.

In cases which come to the surgeon, loss of sensibility to cotton-wool is usually absolute. Loss of epicritic sensibility may be the only sign of the injury, motion being entirely unaffected.

Motor symptoms.—Paralysis of muscles supplied by the injured nerve may result from incomplete division, usually at once, but sometimes later from compression of fibrous tissue.

In the least severe cases the muscles, though paralysed, retain their irritability to the interrupted current. Usually the reactions considered by the writer typical of incomplete division are present. About the tenth day after the injury the muscles do not respond to the interrupted, but react in a characteristic manner when stimulated with the constant current. The strength of current necessary to call forth the contraction is less than on the sound side; the contraction so produced is brisk as compared with that seen when the reaction of degeneration is present, and polar reversal is absent.

Neuritis.—Pain is more common after incomplete than after complete division, and may be accompanied by hyperalgesia of the skin, sometimes by glossy skin and changes in the growth of the nails (causalgia). (*See also* Traumatic Neuritis, p. 406.)

These symptoms rarely arise immediately, a latent period of a few days to three weeks being present. The pain is of a "burning" character, and most severe when there has been an incomplete anatomical division, and is most often seen after gunshot wounds

In civil life the condition is rarely severe; it may result from

penetrating wounds, primary injury in association with fractures, or a direct blow. *The painful* area is usually extremely tender, and maps out the full distribution of the injured nerve. Glossy skin is only present in the severe cases.

Loss of sensibility *may be present, varying with the* nerve injured and the degree of injury; it usually affects epicritic sensibility only. The pain after a short time affects the patient's general condition; he rapidly loses self-control and becomes "hysterical."

Changes in the skin are little marked unless the injury has resulted in protopathic loss, when they may resemble those seen after complete division. As after complete division, the changes in the nails will depend upon the extent of the loss of movement.

When *neuritis supervenes the skin* may sweat profusely. In some cases the subcutaneous tissues appear to be increased, and the nails may become more curved and grow faster than those of the unaffected hand. *Blisters may make their appearance and break down to form* ulcers; these may appear not only over the area of sensory loss, but often over the hyperalgesic area as well.

Diagnosis.—The complete diagnosis consists in the discovery of the nerve injured, and of the position and degree of the injury. In the differential diagnosis must be considered lesions of nerve-roots and of the spinal cord, and hysterical conditions.

Spinal cord.—Difficulties in diagnosis may arise in injuries of the cervical *and sacral regions of the cord due to fracture dislocations of* the spine. Careful consideration of the nature of the sensory loss and of the grouping of the affected muscles will always enable the *diagnosis to be made.*

Hysterical affections.—This type of functional nervous disorder may follow any form of injury, but it is particularly when complicating fracture or operations, or when associated with organic nerve injury, that difficulties arise.

The condition is most often seen in healthy males who may show no other hysterical manifestations. As a rule, loss of sensibility and paralysis are both present, but either may be found alone, the former *more often* than the latter. The loss of sensibility is to all forms equally—a variety of loss that does not occur after any peripheral-nerve, posterior-root, or spinal-cord injury; its upper *limit usually* surrounds the limb, often at the level of a joint.

The paralysis may persist unchanged for years, and marked muscular wasting *will then occur.* The *paralysis* is, as a rule, flaccid. In some cases contractures are present, differing from those seen as the result of injuries to nerves, in that all the muscles are *affected, not* only those on the same side of the limb as the contracture.

The loss of sensibility is diagnostic, and the flaccid paralysis with

retention of electrical reactions typical; but when complicating a nerve injury it gives rise to difficulty.

Treatment.—The nutrition of the parts supplied by the injured nerve must be maintained, and overstretching of paralysed muscles and contracture in their opponents prevented until conduction is restored.

Unless the paralysed muscles are kept relaxed by suitable apparatus until voluntary power is restored, deformity may be permanent although nerve recovery is perfect.

The apparatus used must be removed daily, and massage and systematic passive and active movements carried out. This may be supplemented by stimulation with the interrupted current, and by excitation of the paralysed muscles with whichever form of current will elicit a response. As soon as voluntary power begins to return, splints may be removed; the recovering muscles must be actively exercised every day, and massage continued until recovery is complete.

Cases submitted to suture are treated on the above lines as soon as the wound has healed.

Treatment of nerve injury in accidental wounds.—If the nerve is found incompletely divided the gap should be closed by a catgut stitch If possible, the nerve should be placed in contact with healthy muscle or fat.

If the nerve is completely divided, primary suture must be performed. If its ends are lacerated they should be trimmed transversely with a sharp scalpel. If divided at two or more levels the loose portion or portions should be sutured in. If the ends cannot be brought together, one of the methods mentioned later must be used (*see* p 401) Care must be taken that the peripheral end is not rotated longitudinally.

Sterile catgut is the best suture material It is not necessary to use hardened gut unless there is tension on the stitch; in this case catgut hardened to resist absorption for at least fourteen days should be employed. Non-absorbable material, such as silk, Pagenstecher or linen thread, should never be used for suturing nerves. It remains as a foreign body in the nerve and may give rise to trouble months after primary suture. In most cases one stitch only is necessary. The suture should be passed with a round needle through the whole thickness of the nerve at right angles to its axis, and tied with just sufficient force to bring the ends into apposition.

After suture the junction may be surrounded with Cargile membrane, but only if it cannot be placed in contact with healthy muscle or fatty tissue. The skin wound having been sutured, the limb must be put up on a splint, so arranged as to avoid tension upon the junction and to secure relaxation of the paralysed muscles.

Treatment of subcutaneous injuries.—In all cases in which the whole brachial plexus is injured in adults by overstretching, immediate operation should be carried out. In all other cases the limb should be put at rest on a splint with the paralysed muscles relaxed. Daily massage should be employed until such time has elapsed as will enable the diagnosis of the degree of injury to be made. If at the end of a fortnight the reaction of degeneration has developed in the paralysed muscles, the nerve should be exposed.

If the division is obviously incomplete, relaxation of the muscles is to be kept up and daily massage employed until voluntary power returns, when the splint may be discarded and active movement encouraged. The massage should be continued until recovery is perfect.

If a nerve becomes secondarily involved in fibrous tissue, or pressed upon by bone, or if, in a case of incomplete division, in spite of appropriate treatment the condition does not improve, exploration should be undertaken, the nerve freed, the cause of the pressure removed, and means taken to prevent the nerve from again becoming adherent.

Secondary suture—This term should be restricted to cases in which suture is performed after degeneration has occurred. The operation may be divided into three stages:

1. Identification of the ends of the nerve.
2. Freeing and freshening the ends of the nerve.
3. Re-establishment of anatomical continuity

1. The incision should be over the line of the nerve and sufficiently long to expose the trunk well above and below the seat of the injury.

2. The bulb, with the fibrous tissue which is usually found surrounding and uniting the two ends, should then be well freed and the nerve stretched. After this has been done the bulb on the central end should be removed with a sharp scalpel. From the lower end only the fibrous upper extremity need be removed.

3. Catgut (hardened) should be used for suture material. If there is a gap between the ends of the nerve, extensive freeing will add at least an inch in the arm. Additional length may be gained by stripping up branches. In the case of the ulnar nerve, transposition to the front of the internal condyle will add two inches; the musculo-spiral may be transferred to the front of the humerus with a gain of about an inch. If the ends still cannot be approximated, in spite of flexion of the joints over which they pass, the bulbs may be brought together as close as possible by thread and the wound closed. Gradual extension should be started in about a fortnight, and as a rule full extension is reached in six to eight weeks, when a second operation will usually enable suture to be performed

After closure of the wound the limb should be kept in a position

that relaxes the nerve and the paralysed muscles This position must be maintained until the wound is soundly healed, and then very gradually corrected.

Nerve injuries complicating fractures.—In primary injury to the musculo-spiral nerve complicating a fracture of the humerus, or to the external popliteal in fracture of the fibula, operation should be carried out at once, the condition of the nerve investigated, and the appropriate treatment adopted.

In most cases, however, the nerve injury is not discovered until the splints are removed. If signs of complete division are present, operation must be performed, the nerve being exposed and treated on the usual lines.

When the signs are those of incomplete division the limb should be kept at rest and the usual treatment carried out. If improvement does not occur the nerve must be cut down upon and the cause of the pressure removed. It sometimes happens that the involvement comes on some weeks or months after the injury; in these cases operation should be performed without delay.

Treatment of gunshot wounds.—These should be treated upon the lines already laid down, remembering that primary suture is inadvisable in most cases under the conditions obtaining in war-time. In all operations on nerves after gunshot injuries, great care must be taken to avoid operation until the risk of lighting up residual infection has ceased to exist; some months must elapse between healing of a septic wound and the operation for nerve suture.

Nerve-bridging.—The methods which have been employed fall into four groups, but it is not often that the means mentioned on p. 400 will fail to enable the ends to be brought together:

1. Transference of a portion of nerve from another source (nerve transplantation).
2. Provision of a path along which the nerve may regenerate (tubular suture, flap operations, etc.).
3. Utilization of neighbouring nerves (anastomosis).
4. Shortening the limb by the resection of bone.

1 In this group a portion of nerve from the patient (*auto-transplantation*), from another individual (*homo-transplantation*), or from an animal (*hetero-transplantation*) is sutured into the gap between the ends of the nerve When this method is employed the grafts should be of sufficient size; if several portions are used, it is called a "cable" graft

2. The operations in this group aim at the provision of a path, free from fibrous tissue, along which the new axis-cylinders may develop. This was first attempted by Assaky, who brought the ends of the nerve as near together as possible by catgut sutures which bridged over the gap. It has been improved by the introduction of tubular suture (Vanlair), in which, in addition, the ends of the nerve are surrounded by a tube of decalcified bone, aluminium, collodion, preserved and hardened animals' arteries, or, best of all, a resected portion of one of the patient's superficial veins.

The results of tubular suture are better than those obtained by hetero-transplantation.

Recent experience has proved the failure of operations of this type.

4. The fourth method, originally recommended by Löbker, is only justifiable when non-union of the bone is present in addition to the nerve injury.

The method to be employed for restoration of continuity will depend upon the nerve injured and the size of the gap The method of election is auto- or homo-transplantation: in the former the radial or internal saphenous nerves may be used, in the latter a nerve of suitable size from a recently amputated limb. It matters not at all whether a sensory, motor, or mixed nerve is employed. This operation is most often necessary in cases of injury to the musculo-spiral nerve.

If neither auto- nor homo-transplantation is practicable, tubular suture shoul
over
into
the junction.

Recovery after complete division of a nerve.—After division of a nerve, followed by suture, there is always an interval before the commencement of restoration of function; this varies with the age of the patient, the nerve injured, the distance of the injury from the periphery, the method of healing of the wound, and the variety of suture, being, as a rule, more rapid in the young and in cases of primary suture, and greatly retarded by inflammation.

Sensory recovery is divided into three stages (Fig. 725, A, B, C):

1. Restoration of sensibility to prick.
2. Restoration of sensibility to light touch and minor changes of temperature.
3. Restoration of the power of localization.

The first stage of sensory recovery commences, in uncomplicated cases, between six and sixteen weeks after suture, and a prick is usually everywhere appreciated in from four to twelve months after suture.

The interval between the end of the first and the beginning of the second stage varies with the kind of suture and the distance from the periphery of the point of section. After division of nerves at the wrist, followed by primary suture, an interval of more than about six weeks is unusual unless suppuration has occurred.

The whole of the affected area is sensitive to cotton-wool in from twelve to eighteen months after suture. The sensibility of the part is at this time by no means perfect. If a needle is dragged across the skin from normal to affected parts, as soon as the old boundary for the loss of light touch is reached the stimulus seems to become

more diffuse; the patient says that it tingles or is more uncomfortable, and often withdraws the limb. While this area of changed sensibility is present the compass test is always defective.

Improvement in the power of accurate localization constitutes the third stage of recovery. Until localization is perfect the part is useless for delicate work. At least two years, often three, elapse between the date of suture and complete sensory recovery.

Motor recovery.—At a time varying with the distance of the point of suture from the periphery the muscles regain their voluntary power. This return is usually preceded by a change in the electrical reactions of the affected muscles; they become identical with those of incomplete division. Irritability to the interrupted current is usually present on the same date as the first return of voluntary power is noticed.

Prognosis after primary suture.—Complete recovery may occur after primary suture. Sensory recovery may be perfect and voluntary power restored to the affected muscles, the part regaining a condition indistinguishable from normal.

Recovery after secondary suture.—Instances of "rapid restoration" of sensibility after this variety of suture have been recorded. In none of the cases in which I have performed secondary suture from four weeks to five years after division was any recovery of sensibility noticed before the thirtieth day.

Although motor and sensory recovery follow the same stages as after primary suture, there are slight differences. There is greater variability in the time at which the various stages of sensory recovery begin The time necessary for the commencement of the first stage of sensory recovery may be shorter, because the changes in the peripheral end necessary to regeneration are advanced at the time of suture. But usually it is much longer, and the interval between suture and the commencement of the second stage of recovery almost double as long Complete sensory recovery is unusual

Much less variation occurs with regard to motor recovery, but the time necessary is almost always longer.

Prognosis after secondary suture.—It is at present impossible to say how long after the injury successful secondary suture is possible, but motor recovery is unlikely if operation is delayed longer than three years.

The variations in the time at which recovery commences appear to bear no relation to the interval between injury and operation, but have a close connexion with the method of healing of the accidental wound, suppuration retards the time at which the first stage of recovery commences

The prognosis depends also, to a certain extent, upon the nerve

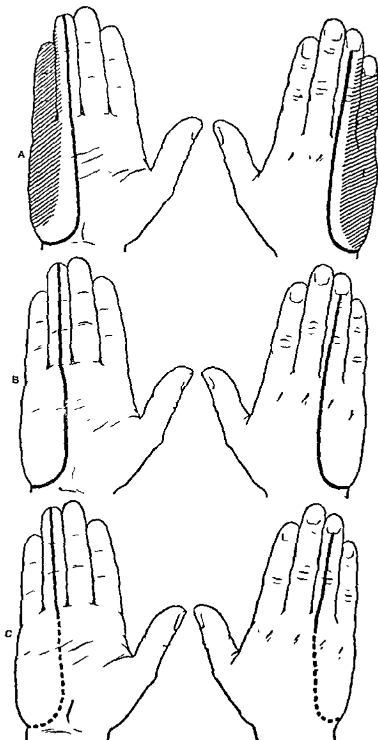


Fig. 725.—To illustrate the stages in recovery of sensibility after complete division of the ulnar nerve. (*See* text, p. 402.)

In this and in following diagrams the area included within the firm line is that of loss of sensibility to light touch, the area within the broken line, that of partial recovery of sensibility to light touch the shaded area, that of loss of sensibility to prick.

injured; for example, recovery may be expected to become perfect after secondary suture of the musculo-spiral, but is unlikely to become so after secondary suture of the median or ulnar. The power of performing delicate manual work will probably never be regained after secondary suture of one of these nerves.

In all cases sensory recovery up to the end of the first stage is to be expected; this is important, as recovery up to this stage abolishes the tendency to the formation of ulcers.

Complications arising during recovery.—Pain is usual during the first two or three days after suture, but rarely needs treatment; if severe, it points to an infective neuritis; the wound should be inspected, and, if necessary, opened up and drained. If this has been done, the condition of the nerve should be explored at a later period when the wound has soundly healed. When suppuration has taken place, gradual deterioration of function may follow a period of improvement, due to involvement of the junction in fibrous tissue; this usually occurs after silk has been used as a suture.

Recovery after incomplete division.—*After incomplete* division, both forms of sensibility (epicritic and protopathic) return together, commencing at a date which varies with the degree of the injury, and the distance of the injury from the periphery, from about three weeks at the wrist to six months in the brachial plexus. As a rule, complete recovery rapidly follows. Muscular recovery begins at a time which varies in the same way. In cases in which the muscles, though paralysed, retain their irritability to the interrupted current, recovery commences in three or four weeks, sometimes earlier, and soon becomes perfect. This degree of injury is seen most often as the result of compression of the musculo-spiral nerve, as in crutch or postanæsthetic paralysis. If the reactions typical of incomplete division are present, a much longer time elapses before recovery begins.

After neurolysis, or when the nerve has been relieved from any form of pressure, recovery follows exactly the same lines.

Prognosis.—This is, on the whole, good Motor power and irritability to the interrupted current are restored, and perfect sensibility regained within a year in most cases. Occasionally, particularly in incomplete anatomical division, tenderness may develop in the distribution of the affected nerve, necessitating a complete resection of the damaged portion, followed by end-to-end suture; in other cases gradual deterioration of function occurs.

TRAUMATIC NEURITIS

Two forms of "neuritis" are recognized: one in which the connective-tissue sheath of the nerve, funiculus, or nerve-fibre is affected

—interstitial neuritis; a second in which the nerve-fibres themselves suffer—parenchymatous neuritis, usually the result of poisons circulating in the blood, but occasionally secondary to the presence of an interstitial neuritis, or, more strictly speaking, a perineuritis. Traumatic neuritis belongs to the first group.

Clinically, two types of neuritis due to injury are met with: one following *injuries of nerves, either in continuity or in their terminal* branches, exemplified by the condition underlying causalgia (*see* p. 397) and the involvement of nerves in amputation stumps; the other due to long-continued slight mechanical injury, typified by the chronic neuritis of the ulnar nerve arising a considerable period after injuries near the elbow-joint (*see* p. 422). The former group is characterized by pain, the latter by motor symptoms.

Neuritis following injuries of nerves in their continuity is uncommon. An acute neuritis giving rise to pain occurs rarely a few days after suture. When non-absorbable suture material has been used, symptoms of neuritis may appear months after operation. Neuritis more often complicates incomplete than complete, and anatomical than physiological division. It is seen in its most typical form after gunshot wounds of nerves (*see* p. 394). In civil practice it is *even less common, but may arise in penetrating wounds of nerve*, in nerve injuries in fractures, as the result of a blow, or from overstretching. In all cases there is a latent period of from one to three weeks before the onset of symptoms. Pain is first noticed, often of a burning or boring character, accompanied by tenderness over the "full" distribution of the affected nerve, and in severe *cases* by changes in the skin.

A nerve may be affected by spread of inflammation from surrounding parts, but this is of very rare occurrence.

Pain may follow involvement of terminal branches of nerves in scars or amputation stumps, particularly in the fingers. As the result of the injury chronic neuritis is set up. The portion of nerve removed at operation *invariably* shows fibrosis. *Pain is widespread, and is* usually accompanied by tenderness involving the whole distribution of the affected nerve or branch, and associated with changes in the skin, its colour becoming pinkish-blue, especially in cold weather. The widespread pain is undoubtedly "referred" in its early stages, but if the cause is not removed an ascending neuritis *will certainly* be set up.

In severe cases muscular wasting, with paresis and paralysis of the muscles supplied by the nerve or root of which the affected twig is a branch, may occur. When symptoms arise as the result of the irritation of the end-bulbs after amputation of a limb, *muscular* twitchings often accompany the pain.

Treatment.—If relief does not speedily ensue from rest of the limb, the nerve should be exposed above the seat of injury and injected with 60-per-cent. alcohol. If pain recurs the damaged portion of the nerve should be removed and continuity re-established.

When pain follows a wound of a terminal filament of a nerve, operation should be undertaken. An incision should be made around the scar or its tender portion; this should be lifted up and the tissues beneath *carefully* dissected to discover the nerve branch affected, which is then cut short.

When neuritis follows nerve involvement in amputations of the fingers, the stump should be palpated for tender spots pointing to the seat of injury, the scar excised, and the digital nerves dissected out and cut short. More bone may have to be removed to permit the flaps to meet without tension.

In involvement of limb nerves the bulb is to be removed, together with one or two inches of the nerve, and care taken to prevent re-involvement or adhesions.

Careful **after-treatment** is necessary. The part should be kept at rest and gentle massage and perhaps stimulation with the constant current applied until pain and tenderness have ceased. When complicated by muscular symptoms the usual treatment must be carried out In cases in which local treatment has failed, cataphoresis may relieve; but if efficient local treatment fails, nothing remains but division of posterior roots (*see* p. 395).

INJURIES OF SPECIAL NERVES

The 2nd, 3rd, 4th, 5th, and 6th nerves may be involved in cranial traumata, accidental or operative, in inflammation of surrounding parts, and by the pressure of tumours. The symptoms produced correspond to the functions of the affected nerves.

It is occasionally desirable to resect a portion of the lingual nerve for the relief of pain in epithelioma of the tongue. This operation should be carried out through a trephine opening in the ascending ramus of the jaw, its centre being situated at the junction of a line drawn backwards from the alveolar margin and one drawn upwards from the angle of the jaw

Facial Nerve

Facial palsy may be due to cerebral lesions above the pons, to nuclear injury, or to damage to the facial nerve itself; we are here chiefly concerned with the third variety.

A cerebral cortical lesion usually produces palsy of part of the opposite side of the face; one acting between the cortex and the deep nuclei of the nerve causes paralysis of the lower half of

—interstitial neuritis; a second in which the nerve-fibres themselves suffer—parenchymatous neuritis, usually the result of poisons circulating in the blood, but occasionally secondary to the presence of an interstitial neuritis, or, more strictly speaking, a perineuritis. Traumatic neuritis belongs to the first group.

Clinically, two types of neuritis due to injury are met with: one following injuries of nerves, either in continuity or in their terminal branches, exemplified by the condition underlying causalgia (*see* p. 397) and the involvement of nerves in amputation stumps; the other due to long-continued slight mechanical injury, typified by the chronic neuritis of the ulnar nerve arising a considerable period after injuries near the elbow-joint (*see* p. 422). The former group is characterized by pain, the latter by motor symptoms.

Neuritis following injuries of nerves in their continuity is uncommon. An acute neuritis giving rise to pain occurs rarely a few days after suture. When non-absorbable suture material has been used, symptoms of neuritis may appear months after operation. Neuritis more often complicates incomplete than complete, and anatomical than physiological division. It is seen in its most typical form after gunshot wounds of nerves (see p. 394). In civil practice it is even less common, but may arise in penetrating wounds of nerve, in nerve injuries in fractures, as the result of a blow, or from overstretching. In all cases there is a latent period of from one to three weeks before the onset of symptoms. Pain is first noticed, often of a burning or boring character, accompanied by tenderness over the "full" distribution of the affected nerve, and in severe cases by changes in the skin.

A nerve may be affected by spread of inflammation from surrounding parts, but this is of very rare occurrence.

Pain may follow involvement of terminal branches of nerves in scars or amputation stumps, particularly in the fingers As the result of the injury chronic neuritis is set up. The portion of nerve removed at operation invariably shows fibrosis. Pain is widespread, and is usually accompanied by tenderness involving the whole distribution of the affected nerve or branch, and associated with changes in the skin, its colour becoming pinkish-blue, especially in cold weather. The widespread pain is undoubtedly "referred" in its early stages, but if the cause is not removed an ascending neuritis will certainly be set up.

In severe cases muscular wasting, with paresis and paralysis of the muscles supplied by the nerve or root of which the affected twig is a branch, may occur. When symptoms arise as the result of the irritation of the end-bulbs after amputation of a limb, muscular twitchings often accompany the pain.

Treatment.—If relief does not speedily ensue from rest of the limb, the nerve should be exposed above the seat of injury and injected with 60-per-cent. alcohol. If pain recurs the damaged portion of the nerve should be removed and continuity re-established.

When pain follows a wound of a terminal filament of a nerve, operation should be undertaken. An incision should be made around the scar or its tender portion; this should be lifted up and the tissues beneath *carefully* dissected to discover the nerve branch affected, which is then cut short.

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the opposite side of the face, usually associated with hemiplegia. If the 7th nerve nuclei are affected, the facial muscles of the same side are paralysed and atrophic, and there is often an accompanying hemiplegia of the opposite side ("crossed paralysis").

Paralysis of the *facial nerve itself* is one of the commonest varieties of peripheral paralysis. About 5 or 6 per cent. of the cases are due to injury, and 6 to 9 per cent. to middle-ear disease.

Symptoms.—These differ according to the level of the injury, and fall into three groups owing to the association of the chorda tympani with the 7th nerve.

Injury to the facial nerve below the point at which the chorda leaves it results most often from penetrating wounds, accidental or operative; it also occurs as a birth paralysis.

Taste is lost over the corresponding half of the anterior two-thirds of the tongue if the nerve is divided while accompanied by the chorda tympani nerve. The nerve may be injured in this situation as the result of operations upon the middle ear or of fracture of the petrous bone, or it may be affected in otitis media.

When the facial nerve is injured above the geniculate ganglion the auditory nerve is usually affected at the same time. It has been stated that a lesion of the facial nerve in this situation produces paralysis of the corresponding half of the soft palate: I have been unable to verify this assertion.

In facial palsy the affected side is flaccid, flattened out, and expressionless; the corner of the mouth droops, the eye closes imperfectly, epiphora frequently results, and the exposed cornea is often inflamed and perhaps ulcerated. Whistling is impossible, and débris accumulates in the sulcus between the jaw and cheek; attempts to whistle, to close the eyes tightly, to frown, or to raise the brows result in asymmetrical grimacing, the paralysed side remaining flaccid.

Prognosis.—A large proportion of the "idiopathic" cases recover spontaneously. Nothing except the investigation of the electrical reactions of the affected muscles will enable an accurate prognosis to be given. If the reactions are those of incomplete division, recovery may be confidently expected. If the true reaction of degeneration is present, recovery apart from operation is unusual. Facial paralysis following an operation on the middle ear is, as a rule, due to incomplete division; recovery takes place in the majority of the cases. In facial paralysis complicating fracture of the base of the skull, whether the involvement is primary or secondary, recovery usually takes place. The partial facial paralysis—paralysis of the lower facial muscles—which is so common as the result of operations in the submaxillary region is rarely permanent.

Treatment.—If the nerve be completely divided the ends

must be sutured, or, if that be anatomically impossible, an anastomosis must be made. When the nerve is involved as the result of middle-ear disease, it is an indication for radical treatment of the ear disease.

If the facial nerve has been completely divided in the petrous bone, either as the result of operation or of fracture, the sooner operative treatment is carried out the better the chance of complete recovery. If the nerve injury is noticed at the time of operation it may be possible to adjust the ends of the nerve in the aqueduct; this has been carried out with success after the lapse of several days, and should be attempted in suitable cases before resorting to nerve anastomosis.

If the reaction of degeneration develops in a case of idiopathic facial paralysis, spontaneous recovery is unlikely, but it is justifiable to wait for six months before resorting to anastomosis.

Different nerves have been recommended and used for anastomosis, and nerve-crossing has been employed instead of it. The hypoglossal is the nerve of choice; dissociated voluntary movement is restored much more quickly than when the spinal accessory is employed. Nerve anastomosis is preferable to nerve-crossing. The complete peripheral operation should be performed and nerve-fibres divided in the sound nerve, either by making an oblique cut into the nerve, or by splitting off a portion and uniting it end-to-end with the peripheral end of the facial.

At first there may be paralysis of the corresponding half of the tongue, but it is quite transient if the wound heals by first intention, and the slight hemiatrophy which supervenes disappears in a few months.

In all the cases of facial nerve anastomosis reported sufficiently long after operation some recovery took place; this commenced earlier and became more complete in cases in which the hypoglossal nerve was used, but up to the present few cases of perfect recovery have been recorded. But in any case we can confidently predict that great improvement will follow the operation, which may in time restore the appearance of the face to normal.

Facial Spasm

The question of surgical treatment occasionally arises in this condition. If the usual treatment by graduated exercises fail, 30 minims of a solution of 75 per cent. of alcohol containing 2 gr. of β-eucaine to the ounce should be injected around the nerve at its exit from the stylo-mastoid foramen. This is followed by facial paralysis if the nerve has been reached. If the spasms recur on the return of motor power, facio-hypoglossal anastomosis should be carried out.

Auditory Nerve

This nerve is usually injured in fractures of the middle fossa of the skull; in 80 per cent. of the cases the facial nerve also suffers.

Vagus Nerve

This nerve rarely *suffers complete division*, but may be injured in operations upon the thyroid gland, ligature of the great vessels of the neck, or removal of tuberculous or malignant glands. It may be pressed upon in the thorax by growth or aneurysm.

If it is divided below the origin of the recurrent laryngeal nerve no symptoms usually result; but when it is irritated during the course of operations the pulse and respiration may temporarily cease

This nerve carries the motor fibres to the muscles of the soft palate and larynx.

Its recurrent laryngeal branch is most often injured during operations on the thyroid. The injury is usually incomplete, and recovery ensues in a short time.

Hoarseness results from paralysis of one recurrent laryngeal nerve. On laryngoscopic examination the cord of the affected side is seen to be fixed midway between adduction and abduction.

Treatment is carried out along the usual lines.

Spinal Accessory Nerve

This nerve is most often injured during operations on tuberculous glands of the neck, it may also be involved in the spinal canal and at the jugular foramen, though in the latter position it is rarely affected alone.

Division of the nerve in the anterior triangle of the neck produces paralysis of the sterno-mastoid and upper part of the trapezius.

In many cases branches of the 3rd and 4th cervical nerves are also injured, producing paralysis of the whole trapezius muscle with considerable deformity and disability.

Immediate suture should be carried out in all cases in which the nerve is divided during the course of an operation. If the accident be not noticed until later, an attempt should be made to perform secondary suture. If it is impossible to find the central end or to bring the ends into apposition the peripheral end should be anastomosed to the anterior primary divisions of the 3rd or 4th cervical nerves.

This nerve is sometimes deliberately divided in the treatment of spasmodic torticollis. It is exposed through an incision made along the anterior border of the sterno-mastoid muscle, with its centre opposite the angle of the jaw. The margin of the muscle is defined and pulled outwards; the nerve is usually seen entering the deep surface of the muscle at this level, or it can be found passing from under cover of the posterior belly of the digastric muscle.

Hypoglossal Nerve

Injury to this nerve is rare. It has suffered most often as the result of gunshot wounds and surgical operations. It may be pressed upon by a

growth extending deeply into the pterygoid region, but in these cases the muscles of the palate and pharynx suffer as well.

[illegible] tongue is flaccid, atrophic, and [illegible] on is pushed to the paralysed [illegible] rticulation are hindered, but [illegible] ced.

Cervical Plexus

Loss or alteration in sensibility in the areas supplied by the sensory branches of this plexus will usually be found after extensive neck operations, but is rarely permanent if the edges of the wound have been accurately apposed and healing has taken place by first intention.

The branches may be injured alone or together; the latter is the more common. The descending branches suffer most often alone.

Phrenic Nerve

This nerve may be injured in operations on lymphatic glands, on the supraclavicular portion of the brachial plexus, or in ligature of the third part of the subclavian artery. Even if both nerves are divided no symptoms may be present while the patient is at rest, but dyspnœa is marked on exertion. If the movements of the abdomen and chest are watched it is seen that the abdomen retracts on inspiration and is forced out on expiration—the exact opposite of the normal movements. When one nerve only is injured careful inspection will show the impairment of movement of the affected side, and X-ray examination will demonstrate the deficient movement of the diaphragm.

The prognosis is good, few cases have succumbed to the immediate result of division of one phrenic nerve.

Immediate suture should be carried out in all cases in which the nerve has been accidentally divided during the course of an operation.

Spasmodic Torticollis

In extreme cases of spasmodic torticollis, in which the general health is suffering and all other treatment, including the injection of alcohol, has failed, section of the upper four or five cervical posterior primary divisions may be performed. (*See also* p. 1074.)

Cervical Sympathetic

The cervical sympathetic cord may be injured as the result of wounds, accidental or operative, or be pressed upon by new growth, or involved in fibrous tissue. Its white rami communicantes from the anterior primary divisions of the 1st and 2nd dorsal nerves may suffer, especially in traction injuries of the brachial plexus, and its pupillary fibres may be affected in injuries of the spinal cord

Division of the cervical sympathetic produces slight enophthalmos and pseudo-ptosis. The pupil on the affected side is smaller than the sound, unless seen in a bright light, when both are equal and contracted. It does not dilate to shade, or in response to the instillation of cocaine or to pinching the side of the neck (cilio-spinal reflex). The affected side of the face does not flush or sweat, and the ear often feels colder to the observer's touch than the sound one. The area of absence of sweating includes, as first pointed out by Purves Stewart, the whole of the upper limb; this I

have been able to confirm. No interference with the heart's action has been recorded.

Stimulation of the sympathetic much more rarely comes under the care of the surgeon; it may occur as the result of the pressure of tumours or aneurysms or the traction of adhesions. It results in exophthalmos, widening of the palpebral fissure, dilatation of the pupil, with, in many cases, flushing and sweating.

The prognosis will depend upon the cause of the injury. Occurring in connexion with injuries of the brachial plexus it is rarely complete; the eye, although remaining contracted on shading, dilates to the instillation of *cocaine*: these cases usually recover. If the paralysis is complete, and the brachial plexus also injured, recovery is unlikely.

Division of the sympathetic in the neck should be treated by primary or secondary suture. Langley and Anderson have proved that the preganglionic fibres of the sympathetic regenerate just as do peripheral nerves If the ends cannot be brought into apposition, nerve anastomosis may be carried out. Resection on one or both sides has been practised without permanent success for such diverse conditions as glaucoma, facial neuralgia, epilepsy, and exophthalmic goitre.

Brachial Plexus

The motor distribution of the roots entering this plexus is important. Although fibres from more than one root can be traced to most of the muscles of the limb, from the clinical standpoint their *supply depends upon one root.*

The following table is obtained from a study of the paralysis resulting from section of individual anterior primary divisions and from experimental excitation during the course of operations:

Fifth cervical . .	Deltoid; biceps; brachialis anticus; supinators; rhomboids; usually the spinati; occasionally the radial extensors of the wrist; rarely the pronator radii teres.
Sixth cervical . .	Pronators; radial extensors of the wrist; clavicular portion of pectoralis major; serratus magnus.
Seventh cervical .	Triceps; extensor carpi ulnaris; extensors of fingers; pectoralis major.
Eighth cervical .	Flexors of wrist; flexors of fingers.
First dorsal . .	Intrinsic muscles of hand.

The distribution of the posterior roots entering into the plexus is of little practical importance. The overlap between adjacent roots is considerable, and it is possible to divide any one without producing sensory loss.

Causation.—Infraclavicular injuries usually result from the pressure of the dislocated humeral head; supraclavicular damage chiefly follows violence applied *to the head or the shoulder*, but may also complicate a cervical rib, a penetrating wound, a fracture of the cervical spine, or a fractured clavicle.

Violence to the head or shoulder due to falls or to traction during birth overstretches the cervical anterior primary divisions; only rarely are the "roots" affected. The traction falls first upon the upper part of the 5th anterior primary division, then upon its junction with the 6th, and after this upon the remaining divisions in order from above downwards.

Both in children and in adults the 5th or 5th and 6th anterior primary divisions are usually involved, producing the Erb-Duchenne type of paralysis (*see* p 414). If the violence affect the plexus from below, the first dorsal suffers, then the others in order from below upwards. An Erb-Duchenne or Klumpke paralysis may remain when the original affection was more widespread.

The immediate lesion consists in a tearing of the nerve sheath, with hæmorrhage; in more severe cases a complete or partial severance of nerve-fibres at different levels may occur. In healing, an excess of fibrous tissue is formed which may prevent regeneration

Symptoms associated with the presence of a cervical rib.—Cervical ribs are commoner in women, and may run in families, but only in from 5 to 10 per cent. of cases do they interfere with conduction in the lower roots. Symptoms do not, as a rule, arise until early adult life, and then, though the ribs themselves are usually bilateral, generally only affect the right side. They may be due not only to a cervical rib, but to a fibrous cord which may run from its extremity, a rudimentary or even a normal first rib; they are the same whatever the cause of the pressure.

The patient suffers from weakness of the limb when tired, muscular wasting, "neuralgic" pains shooting down the inner side to the hand, and sometimes from altered sensibility. Wasting and paresis of the intrinsic muscles of the hand, especially those of the thenar eminence, are usually first noticed. The vessels, as a rule, escape, but the subclavian artery may be sufficiently compressed to cause limited gangrene of the finger-tips.

Operation should be carried out for severe pain or muscular wasting, unless the reaction of degeneration is present. Care must be taken not to injure the sensory branches of the cervical plexus or the nerves supplying the trapezius or serratus magnus. When symptoms have proceeded to those of complete division, operation is unlikely to be successful.

Infraclavicular injuries of the plexus result most often from the direct pressure of the dislocated humeral head, or from attempts made to reduce it by the heel-in-axilla method, but also occasionally from fracture of the upper end of the humerus or of the neck of the scapula.

The whole plexus may suffer, but more often the inner cord alone,

rarely the outer, is affected. In unreduced dislocations of the humerus, pain and tenderness may arise from changes in the nerves due to pressure, and may indicate operation; in other cases, paralysis may supervene from the same cause.

Symptoms produced by injuries of the plexus.—There are three types of brachial plexus lesion due to *supraclavicular injuries* and produced by indirect violence: (1) the whole plexus, (2) the upper-arm type (Erb-Duchenne), and (3) the lower-arm type (Klumpke).

In *infraclavicular* lesions the inner cord and the whole plexus types are the only common ones Here a lesion of the whole plexus often becomes, later, one of the inner cord only.

1. *The whole plexus.*—The symptoms produced by division of the whole plexus will depend to a certain extent upon the level of the injury, whether supra- or infraclavicular, whether in the roots, primary divisions, or cords.

In a supraclavicular division the loss of sensibility is the same, whatever the level of the lesion Epicritic and protopathic sensibility are lost over the whole of the forearm and over the outer surface of the arm in its lower two-thirds, the area overlapping on to the anterior and posterior surfaces. Deep touch is lost over the forearm The sympathetic is usually affected *(see p. 411)*.

When the lesion is infraclavicular the sensitive strip on the inner side of the arm may be absent if, as is so often the case, the injury has been caused by direct pressure.

In cases of complete loss of conduction in the plexus all the muscles of the arm, forearm, and hand are paralysed. The level of the lesion will determine whether the spinati, rhomboids, serratus magnus, and pectorals are paralysed or the sympathetic is involved. In the usual type of complete plexus injury due to indirect violence the pectorals and spinati are paralysed and the sympathetic is involved, but the rhomboids and serratus magnus escape.

2. *Erb-Duchenne paralysis.*—When caused by injury, this usually results from indirect violence, very rarely from a penetrating wound or the pressure of a tumour. It is due to injury of the 5th cervical anterior primary division, alone or with the 6th.

The position of the upper limb is typical. The arm and forearm hang close to the side, with the forearm extended and pronated. The spinati, deltoid, biceps, brachialis anticus, and supinators are paralysed, and occasionally, as first pointed out by Wilfred Harris and Warren Low, the radial extensors of the wrist.

No loss of sensibility accompanies this form of paralysis.

The injury to the 5th anterior primary division may be incomplete, and either physiological or anatomical, leading in the former to

paralysis of all the muscles supplied by the nerve, with the reactions of incomplete division, in the latter to paralysis of the deltoid and spinati muscles, with the development of the reaction of degeneration.

3. *Lower-arm type of paralysis* (Klumpke) —This may arise from overstretching of the first dorsal anterior primary division, from penetrating wounds, or occasionally from involvement in growth. It may be bilateral when due to over-flexion or over-extension of the cervical spine.

All the intrinsic muscles of the hand are affected, and the hand assumes the true claw shape. Sensibility is usually altered over the inner side of the arm and forearm, sometimes also on the ulnar border of the hand The long flexors of the fingers may suffer, but probably the 8th cervical is then also injured. Characteristic orbital symptoms are present, due to involvement of the branches given from this nerve to the cervical sympathetic (*see* p. 411).

The inner cord.—Injury to this cord is most often produced by a subcoracoid dislocation of the humerus, and is rarely complete.

The muscles paralysed are those supplied by the ulnar nerve with, in addition, those intrinsic muscles of the hand supplied by the median.

Sensibility is affected over the inner surface of the forearm and ulnar area of the hand. Usually epicritic sensibility only is lost, but when the division is complete protopathic sensibility is also.

Outer cord.—Injury to this cord is a rare complication of dislocations of the humerus.

Posterior cord.—No difficulty should arise in the recognition of this rare form of injury. The paralysis of the muscles supplied by the musculo-spiral and circumflex nerves, and the alteration in sensibility over the areas of skin supplied by them, are typical. It results most often from a dislocation of the humerus.

Treatment of brachial-plexus injuries.—Exploration should be undertaken at once in all cases in which the whole plexus is affected in the supraclavicular region as the result of indirect violence. When operation is delayed it is usually impossible to identify the individual nerves in the mass of fibrous tissue with which they are incorporated No instance of perfect recovery after secondary suture of the whole plexus has been recorded.

The lesion causing the lower-arm type of paralysis is situated in the 1st dorsal anterior primary division, too high to admit of direct union. The clavicle must be divided, and anastomosis to the 8th cervical anterior primary division will be necessary in most cases.

In all cases any obvious cause of pressure must be removed. Partial injuries and bruises are treated by rest till pain disappears, followed by massage, passive movements, and electrical stimulation.

Brachial birth paralysis is usually caused by overstretching of the plexus, but in some of the less severe cases it may result from the direct pressure of the accoucheur's fingers.

The lesion is produced with almost equal frequency in breech and in vertex presentations, and is usually unilateral, the left arm being more often affected than the right. The whole plexus may be involved, or the paralysis may be of the upper- or of the lower-arm type; the upper-arm type is the most common (80 per cent). When the whole plexus is affected some spontaneous recovery usually occurs; as a rule a residual upper-arm paralysis is left. Paralysis of the lower-arm type is rare, and occurs most often as the result of breech presentations with extended arms, or occasionally after face presentations.

Prognosis.—A large proportion of all cases of brachial birth paralysis undergo spontaneous recovery, but no definite opinion can be given until the child is old enough to have the electrical reactions of the affected muscles tested. Cases with marked tenderness rarely recover completely without surgical interference.

If, when the patient comes under observation, the reaction of degeneration is present, complete recovery apart from operation is unlikely.

Spontaneous recovery has taken place in about 70 per cent. of the cases that have come under my observation. In many the paralysis had completely disappeared by the time the child was brought to have its electrical reactions tested at the age of three months. *Complete spontaneous recovery rarely takes place if no improvement* is noticed by this date.

Treatment.—The upper limb must be kept at rest in a splint with the affected muscles relaxed, and, as soon as all tenderness has ceased, daily massage and passive movement employed, special attention being directed to the pectoral muscles to prevent the pulling forwards of the shoulder which so commonly occurs. If the affected muscles be not relaxed, *permanent deformity may result although the* muscles regain their voluntary power and electrical excitability. The electrical reactions should be tested under an anæsthetic at the end of ten or twelve weeks. If the reaction of degeneration is then present, operation should be undertaken as soon as convenient. *If the* health of the child is not good, delay of a few months will probably affect the final result little, so long as the correct non-operative treatment *is being carried out.*

Long (Posterior) Thoracic Nerve—Nerve of Bell

Paralysis of the serratus magnus, the result of injury, is seen most often in males between the ages of 25 and 40, commonly *on the right* side, and due to carrying weights on the shoulder. It is rare as an

isolated lesion; the lower part of the trapezius is usually affected as well. The nerve is sometimes severed during operations upon the upper part of the axilla, and has been divided during the complete operation for carcinoma of the breast. Paralysis of the serratus magnus and lower trapezius produces a conspicuous "winging" of the scapula. The patient is unable to raise the affected arm in front of the body above the level of the shoulder, or to perform forward pushing movements; any attempt to do so at once increases the winging.

When the serratus is paralysed alone, the deformity when the arm is at rest is hardly noticeable. The patient is unable to raise the arm above the level of the shoulder in front of the body, or to make forward pushing movements above a horizontal plane passing through the shoulder; attempts to perform this latter movement cause the winging to become more marked.

The slight winging of the scapula produced by paralysis of the lower trapezius alone at once disappears on raising the arm above the level of the shoulder in front of the body, thus throwing the serratus magnus into action It is increased when attempts are made to push below the level of the shoulder.

Treatment.—In many cases the injury is incomplete and does not call for operative interference. If the reaction of degeneration develops, operation must be considered. Except in the cases in which the nerve is injured in the course of a surgical operation, direct suture is out of the question, anastomosis to the posterior cord should be carried out if necessary, or the sterno-costal portion of the pectoralis major transplanted from the arm to the inferior angle of the scapula.

Circumflex Nerve

Injury to this nerve is infrequent. The paralysis of the deltoid muscle which is not uncommonly seen as the result of an injury to the shoulder is usually due to injury of its motor fibres as they run in the 5th cervical anterior primary division, and is accompanied by paralysis of the spinati muscles.

The nerve is most exposed to injury as it passes round the neck of the humerus. It may suffer from the pressure of a crutch, or of the head of the humerus in subglenoid dislocations, or be injured in fractures of the neck of the scapula or the surgical neck of the humerus. Its terminal filaments may be injured in those whose occupation entails lying on the side (miners), and may be involved in inflammation of the subdeltoid bursa.

Symptoms.—The deltoid is paralysed, but the head of the humerus does not tend to fall away from the glenoid cavity as it does when the spinati are also affected.

Sensory changes always accompany an injury to this nerve of

sufficient severity to cause paralysis of the deltoid. There is, as a rule, no loss of deep touch.

The **diagnosis** of an injury to the circumflex nerve necessitates careful examination; if there is no sensory change it can certainly be excluded. All the muscles of the shoulder girdle must be examined and the condition of the spinati especially noted.

Treatment.—The injury is most often incomplete, and treatment proceeds on the usual lines. But even if the lesion be complete and the reaction of degeneration present, operation is by no means always necessary. The sensory loss is over an unimportant region, and the paralysis may be fairly well compensated by other muscles. The age of the patient and his occupation must be considered. In most cases sufficient abduction is obtained by training the neighbouring *muscles to take the place of the deltoid. If, however, perfect abduction* is essential, the nerve may be exposed through an incision parallel to the posterior border of the deltoid muscle, and the condition dealt with by operation.

Musculo-Cutaneous Nerve

This nerve may be injured in wounds—accidental, operative, and gunshot—or involved in fibrous tissue after rupture of the biceps. Its branches, particularly the anterior division of the external cutaneous, are not infrequently affected, and filaments are often divided in association with other nerves in wounds in the region of the wrist and forearm.

Musculo-Spiral Nerve

This nerve is most often injured in the lower third of the arm; only in crutch, anæsthetic, ' Saturday-night " paralyses, and the rare penetrating wounds is it affected elsewhere. Most of the injuries are the result of direct pressure, from fractures of the humerus, from crutches, and from the edge of an operating table; rarely from the dislocated head of the radius The nerve occasionally suffers in accidental wounds, or in those made during operations on the humerus. Its posterior interosseous branch may suffer in *dislocations of the upper* end of the radius and in fractures of its neck, and has been injured during operations as it passes through the supinator brevis. The radial nerve may be divided in penetrating wounds in the region of the wrist, usually in association with branches of the external cutaneous nerve.

Injury to the nerve occurs in about 8 per cent. of the cases of fracture of the humerus, most often in those involving the lower and middle thirds. The injury is usually secondary (*see* p. 394), and the division is physiological.

Motor symptoms.—The wrist is dropped, and after some weeks there is a marked prominence on the dorsum of the hand, due to overstretching of the dorsal ligaments of the wrist and subluxation of the carpus. The patient is unable to extend the wrist owing to the paralysis of the extensores carpi ulnaris et radialis; the paralysis of the extensor communis digitorum makes active extension of the fingers at the metacarpo-phalangeal joints impossible. All the extensor muscles of the thumb are paralysed. Paralysis of the triceps is unusual, the nerve usually being involved below the point at which its branches of supply are given off.

Sensory symptoms.—No loss of sensibility results from complete division of this nerve in the lower third of the arm. But division above the point at which its external cutaneous branches are given off, or division in the lower third, together with injury to these branches or to the posterior division of the external cutaneous nerve of the forearm (musculo-cutaneous), produces a definite loss of sensibility on the dorsum of the hand, the extent and degree of which vary according to the relative size of the posterior branch of the external cutaneous.

For prognosis and treatment, *see* under Radial Nerve, p. 420.

Radial Nerve

Section of this nerve in the upper two-thirds of the forearm produces no loss of sensibility, but division in the lower third of the fore-

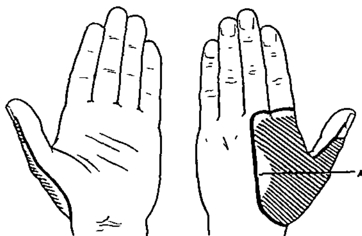


Fig. 726.—Loss of sensibility following division of radial and external cutaneous nerves.

The unshaded area at A represents the part sensitive to light touch but insensitive to prick

arm, after it has become associated with branches from the posterior branch of the external cutaneous nerve, causes a definite loss of

sensibility to light touch (Fig. 726). Simultaneous division of the external cutaneous nerve, or of its posterior branch, increases the extent of the loss of appreciation of light touch and also causes loss of sensibility to prick (Fig. 726).

Prognosis.—In most of the "Saturday-night," crutch, and post-anæsthetic palsies the affected muscles retain their irritability to the interrupted current, and recovery may be confidently anticipated in from seven to twenty-eight days. When the typical reactions of incomplete division are present, recovery commences in from four to twelve weeks after removal of the cause. If the reaction of degeneration is present, recovery rarely ensues without resection of the damaged portion and end-to-end suture.

After primary or secondary suture the prognosis is better than after suture of any other nerve of the body. Perfect recovery may be expected in about a year from the time of suture.

Treatment.—It is essential that the affected muscles be kept from overstretching until voluntary power is regained; the wrist must not be allowed to remain in the dropped position, but should be supported on a "cock-up" splint.

Ulnar Nerve

This nerve suffers most often in penetrating wounds, usually in the neighbourhood of the wrist. Near the elbow it may be injured by a direct blow, by a fracture or dislocation during excision, or rarely by a penetrating wound. It occasionally suffers in certain occupations entailing constant movements at the elbow, such as glass-working or cigarette-making.

The **symptoms** produced by division of the ulnar nerve must be studied in three situations: (1) at or above the point at which the motor branches to the forearm muscles are given off (at the elbow); and at the wrist, (2) above and (3) below the point at which its dorsal branch is given off

(1) At the elbow.—*After division of the nerve here* the hand assumes a characteristic position: the index and middle fingers are extended at the metacarpo-phalangeal joints owing to paralysis of the interossei muscles; the little and ring fingers are hyperextended at these joints in consequence of paralysis of the lumbricales in addition. All the fingers are flexed at the interphalangeal joints, the flexion being most marked in the little and ring fingers; the little finger is held abducted

The paralysis of the flexor carpi ulnaris is often concealed by the action of the palmaris longus. The little and ring fingers can be flexed to a slight degree by the slips of the flexor sublimis attached to them and supplied by the median nerve, but flexion of the terminal

phalanx of the little finger is always impossible. All true movement of abduction and adduction of the fingers is lost, but false abduction (accompanied by extension of the basal phalanges) can be carried out by the extensor communis digitorum. The adductor muscles of the thumb are paralysed, but their action can be simulated by means of the long extensor and flexor muscles of the thumb (false adduction); it is always accompanied, however, in the former case by extension of the terminal phalanx and outward rotation of the thumb, in the latter by flexion and inward rotation.

Sensory symptoms.—Sensibility to light touch is lost over the area included within the black line in Fig. 727. The extent of proto-

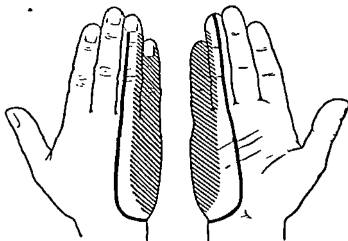


Fig. 727.—Loss of sensibility after complete division of ulnar nerve.

pathic loss varies; in some cases the little finger and the extreme ulnar border of the palm only are affected; in others the area is nearly as large as that over which epicritic sensibility is lost. Deep sensibility is usually lost over an area almost as extensive as that insensitive to prick.

(2) and (3) Division at the wrist.—Accidental division of the nerve in the lower part of the forearm is rarely unaccompanied by division of tendons.

Injuries of this type frequently divide the nerve below the origin of its dorsal branch.

After injury in either situation (above or below the dorsal branch) all the intrinsic muscles of the hand supplied by the ulnar nerve are paralysed. The loss of sensibility after division of the whole nerve at the wrist, above the origin of the dorsal branch, resembles that seen after division at the elbow, with the exception that deep sensibility is usually retained.

After division of the nerve below the origin of its dorsal branch, the loss of sensibility is much less and may be easily overlooked. (Fig. 728.)

Treatment.—Special care is necessary to prevent the development of the ulnar "claw" hand. During recovery a splint should be worn until the muscles regain voluntary power, to keep the fingers extended at the interphalangeal and flexed at the metacarpo-phalangeal joints. Otherwise, stretching of the interossei muscles and changes in the interphalangeal ligaments prevent perfect recovery of function.

Prognosis.—Complete recovery, both sensory and motor, is possible after primary suture, but never occurs after secondary suture.

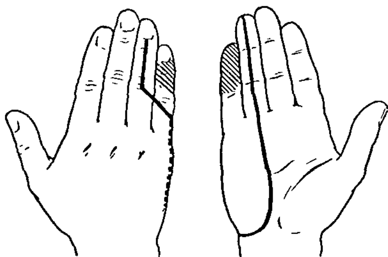


Fig. 728.—Loss of sensibility following division of ulnar nerve below its dorsal branch.

ULNAR NERVE INJURIES IN FRACTURES, RECENT AND REMOTE

The injury occurs in fractures involving the internal condyle, and the division is usually physiological and incomplete.

Interference with the functions of the ulnar nerve may arise many years after an injury in the region of the elbow which has led to permanent deformity; in one of my cases the interval was twenty-seven years. In most recorded instances the accident occurred in childhood, and in several cases no history of injury could be obtained.

The injury producing the deformity has been, in most cases, a fracture or epiphysial separation of the lower end of the humerus which has led to a marked cubitus valgus, often with obliteration of the ulnar groove behind the internal condyle.

Pain in the distribution of the nerve is generally the first symptom, soon followed by wasting and weakness in the muscles supplied. In a few cases the latter was the first symptom noticed. As a rule, the signs are those of incomplete division. The patient may be unaware of any deformity at the elbow.

The ulnar nerve is usually enlarged into a spindle-shaped swelling behind the internal condyle.

The symptoms are the result of a local interstitial neuritis due to repeated friction or pressure upon the nerve. If this is not treated, complete physiological division results.

Treatment.—In the least severe cases, rest will entirely relieve the symptoms for a time, but recurrence inevitably takes place on resumption of work.

Operation is useless unless the patient will give up sufficient time to allow of muscular recovery.

When the signs are those of incomplete division, the nerve should be exposed behind the internal condyle, and a groove in the bone chiselled for it or the nerve transplanted to the front of the condyle.

When complete division has occurred, the spindle-shaped swelling should be excised in addition, and end-to-end suture performed.

DISLOCATION OF THE ULNAR NERVE

Abnormal mobility (subluxation) of the ulnar nerve is common and causes no symptoms, but predisposes to dislocation, in which the nerve passes forwards over the internal condyle.

Traumatic dislocation of the ulnar nerve usually occurs in males between 20 and 30, and only when the elbow is flexed, sudden and violent flexion rupturing the fascia which keeps it in position.

Symptoms.—Suddenly, after an injury to the elbow, pain is felt in the distribution of the ulnar nerve, usually followed by alteration in sensibility and by weakness of muscles. Symptoms are relieved by rest, and recur with frequency when use of the arm is resumed; the repeated irritations to which the nerve is subject in passing over the internal condyle may lead to an interstitial neuritis and the formation of a spindle-shaped swelling on the nerve, with a gradual deterioration of function which may progress to complete division. Occasionally the dislocation arises without sudden injury; in these so-called congenital cases, the supporting fascia gradually stretches and at last allows the nerve to pass over the condyle.

Treatment.—Operation is necessary if symptoms pointing to interference with the functions of the nerve are present. The nerve should be exposed and freed through a long incision behind the internal condyle; it may be transferred to the front of the internal condyle.

or the groove in the bone may be deepened, if necessary, the nerve wrapped in a tube of fatty subcutaneous fascia to prevent adhesions, and finally the bony groove converted into a canal by stitching a portion of the fascia of the triceps over it. In *neglected cases*, in which a spindle-shaped swelling is found on the nerve and the signs of complete division are present, the damaged portion must be resected; this, however, is rarely required.

Median Nerve

This nerve may be injured through wounds near the wrist, in fractures of the lower end of the humerus, of the radius, or of both bones of the forearm (in this last variety of fracture its anterior interosseous

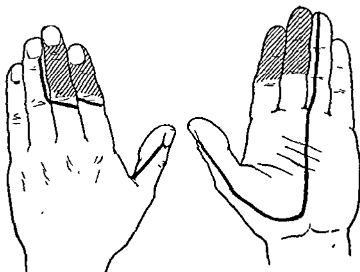


Fig. 729.—Loss of sensibility following division of median nerve.

branch may be injured alone), by splint pressure, or by overstretching in falls on the outstretched hand, or it may be involved in Colles's fracture—in these last two varieties the palmar cutaneous branch usually escapes injury; or it may be affected in various occupations, such as those of cigarette-makers, carpenters, and professional golfers.

Sensory symptoms.—*If the median nerve is divided at the wrist*, deep touch can be appreciated over the whole of the affected area.

Sensibility to light touch and to prick is lost over the areas shown in Fig. 729. The loss of sensibility to prick varies within wide limits.

In many injuries near the wrist, tendons are also divided; this usually results in the appearance of an area insensitive to deep touch almost as extensive as the area of loss of sensibility to prick.

Division of the nerve at the elbow or even in the axilla does not increase the extent of the loss of epicritic or protopathic sensibility, but usually affects deep sensibility.

Motor symptoms.—After division at the elbow the most important symptom is inability to flex the terminal phalanx of the thumb owing to the paralysis of the flexor longus pollicis; the index finger can only be flexed at its metacarpo-phalangeal joint by means of the interossei muscles attached to it. Pronation of the forearm is feeble, and only possible by allowing the weight of the arm to have play.

After division at the wrist the abductor-opponens group of muscles and the outer two lumbricales only are affected. The abductor pollicis takes the thumb away from the index finger in a plane at right angles to that of the palm. In testing its action the patient should be asked to touch something held immediately in front of the thumb, the hand being placed with its dorsum on the table.

In opposition the thumb is rotated so that its palmar surface looks towards the palm; for the perfect performance of this movement the action of the opponens pollicis is necessary, but it is often difficult to tell from inspection alone that the movement is being produced by the long flexor of the thumb and the adductor muscles. Palpation over the insertion of the opponens to the metacarpal bone of the thumb may be necessary before coming to any decision with regard to its paralysis.

The branch supplying the abductor-opponens group of muscles may arise in the lower third of the forearm instead of in its usual position immediately below the annular ligament, and so may escape injury in division of the median at the wrist.

Diagnosis.—Injury to the median nerve is frequently overlooked owing to the retention of deep sensibility, the relatively small loss of protopathic sensibility in many cases, the absence of any characteristic attitude such as is seen after injury to the ulnar or musculo-spiral, and the relatively slight paralysis resulting from its complete division.

Prognosis.—The prognosis after division of this nerve is good, better than after a similar injury to the ulnar; the muscular recovery is not liable to be hindered by deformity, hence it is more often perfect, even if no after-treatment is carried out.

Median and Ulnar Nerves

These nerves are not infrequently injured simultaneously in accidentally inflicted wounds near the wrist, or as the result of tight splints used in the treatment of fractures of the forearm. They are occasionally involved in fractures or epiphysial separations of the lower end of the humerus or in fractures of the forearm.

When resulting from wounds near the wrist the division of the median may be incomplete; a not infrequent accident is complete anatomical division of the ulnar nerve accompanied by incomplete anatomical division of the median. The injury to the median is usually sufficient to paralyse temporarily the intrinsic hand-muscles supplied by that nerve.

The areas of loss of sensibility to light touch and loss of sensibility to prick after complete division of the median and ulnar nerves are shown in Fig. 730.

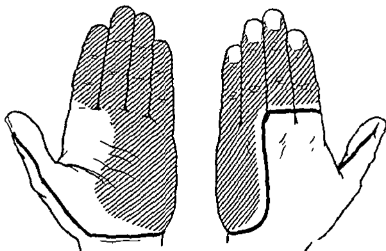


Fig. 730.—Loss of sensibility following complete division of median and ulnar nerves.

Division of the median and ulnar nerves is an accident of great severity. Complete restoration of function is improbable.

Cauda Equina and Conus Medullaris

Injuries to the cauda equina most often result from a fracture dislocation in the lumbar region, but occasionally from a fall on the back or buttocks without any evidence of bony injury; the nerves may be injured alone or with the conus medullaris.

As first pointed out by Thorburn, when the injury is incomplete the nerves injured are usually lower in the series than those spared. For example, interference with the functions of the bladder and rectum, and alterations of sensibility over an area on the buttocks corresponding to the supply of the third sacral roots and those below it (Fig. 731), are present in practically all the cases.

The same changes in the electrical reactions of the affected muscles occur as after injuries of peripheral nerves of corresponding severity.

The sensory loss is of the root type, i.e. the area of loss of light touch is smaller than the area of loss of sensibility to prick.

The sphincter ani is paralysed, and incontinence of fæces results; retention of urine is present at first, followed in many cases by true incontinence; sexual power is usually absent, but the testes retain their normal sensibility, being supplied from a higher level than the anæsthetic skin of the scrotum.

The conus medullaris may be injured alone, or more often with the nerves of the cauda equina. When injured alone, paralysis of the bladder and rectum results, with a small patch of alteration of sensibility over the coccyx. When a larger area of loss is present we

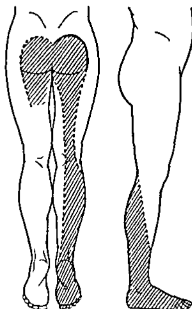


Fig. 731.—Usual loss of sensibility after injury to cauda equina, due to complete interruption of conduction on right side.

must assume that the cauda is injured in addition, unless the injury be purely in the spinal cord.

The following table gives roughly the distribution of the roots to the various muscles; the remarks made in connexion with a similar table for the brachial plexus (p. 412) apply here also.

Third and fourth sacral	Levator ani; sphincter ani; perineal muscles.
Second sacral	Glutei muscles; biceps; semi-membranosus and semi-tendinosus.
First sacral	Intrinsic muscles of the foot; tibialis posticus and other calf muscles.
Fifth lumbar	Muscles of antero-external surface of leg (except tibialis anticus).
Fourth lumbar	Extensors of leg and tibialis anticus.

It is difficult to make this table correct, as lesions of roots are rarer even than in the cervical region.

No difficulty should be experienced in diagnosing a pure cauda lesion. The paralysis is of the peripheral type with segmental distribution The sensory loss has the characteristic features of an injury to posterior roots.

Prognosis is unfavourable. Death seldom occurs as the direct result of an injury to the cauda equina; it will result most often from urinary infection. Complete recovery is rare; in most of the cases spontaneous recovery is incomplete.

Treatment.—In fracture dislocation of the spine involving the cauda equina, laminectomy should be carried out without delay.

In longstanding cases the rules governing operative interference in old injuries of peripheral nerves must be applied.

Anterior Crural Nerve

This nerve has been injured in fractures of the pelvis or the femur, in operations upon psoas abscesses, as the result of such an abscess, and in manipulative treatment of congenital dislocation of the hip-joint. Its division is rarely complete.

The most important symptom is the paralysis of the quadriceps extensor cruris.

Sensation is affected over a well-defined area on the inner side of the leg and an ill-defined area on the antero-lateral aspect of the thigh.

Great Sciatic Nerve

Complete division of this nerve is uncommon. It may be injured in penetrating wounds, in the treatment of congenital or traumatic dislocation of the hip, in military gunshot wounds, or, with other branches of the sacral plexus, in fractures of the pelvis.

Its external and internal popliteal divisions remain separate up to their origin from the plexus This is of great surgical importance, for either nerve may be injured alone. In incomplete injuries of the great sciatic its external popliteal portion more often suffers and may be completely divided without the internal popliteal being affected

Motor symptoms.—All the muscles of the leg are paralysed and all movements of the foot impossible If the nerve is divided in the upper part of the thigh the hamstring muscles are paralysed, but flexion of the leg on the thigh is still possible by means of the gracilis; in longstanding cases this muscle hypertrophies and becomes an efficient flexor.

Sensory symptoms.—There is a widespread loss of sensibility below the knee, as shown in Fig 732. Deep touch is affected over a comparatively small area of the foot only.

Treatment.—During the early stages of recovery the weight of the body must not be allowed to rest on the paralysed foot; perforating ulcers are liable to develop, and may necessitate amputation. The possibility of division of the external popliteal portion alone must be remembered. If after an injury to the great sciatic the reaction of degeneration develops in the external popliteal group of muscles, even although those supplied by the internal popliteal are unaffected, the nerve should be exposed, the damaged portion of

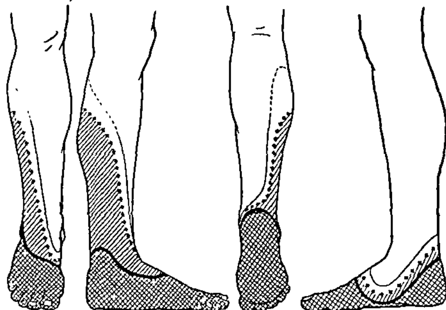


Fig. 732.—Loss of sensibility following complete division of great sciatic nerve.

The area of loss of sensibility to light touch is bounded by a thin line, the loss of sensibility to prick by crosses. The thick line bounds the area of loss of all forms of sensibility, including deep touch.

the external popliteal found by tracing it up from below, separated from the internal, excised and reunited. If motor recovery fails, a suitable surgical boot should be worn, or arthrodesis of the ankle carried out. Amputation may be necessary.

SCIATICA

The term sciatica is loosely applied to all cases of pain in the area of supply of the great sciatic nerve. Under this heading are included (*a*) cases due to pressure upon the nerve or its roots of origin by bony outgrowths, malignant tumours, etc.; (*b*) referred pain from disease of hip-joint and irritation of the branches given off from the sciatic plexus; (*c*) sciatic neuritis, due to exposure, trauma, rheumatism, gout, syphilis, or other toxins. The patient complains of severe

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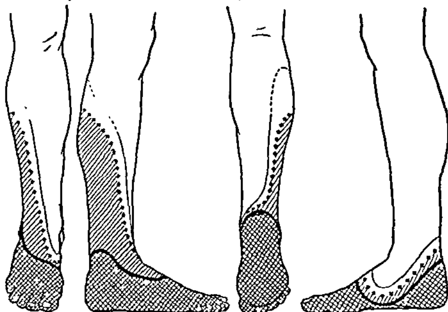


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shooting pain along the course of the nerve and often of its external popliteal branch; this is increased by movement or by pressure over the nerve; any attempts by the surgeon to raise the leg to a right angle with knee extended and ankle flexed are futile. If neuritis is present the nerve is tender.

It is necessary to discover in which group the case can be placed, and to treat the cause. Careful examination must be made, and the spine and hip-joint X-rayed. If the first group can be excluded, rest in bed with a long splint and weight extension is the most efficient treatment. Sedatives, even morphia injections, may be necessary. If this treatment fails, 80–100 c.c. of normal saline containing 1 per cent. of β-eucaine (Lange) should be injected into and around the nerve at the sciatic notch. Alcohol should never be used for this purpose, as it produces nerve degeneration and consequent paralysis of muscles of the leg.

As a last resort the sciatic nerve should be exposed at the lower border of the gluteus maximus and thoroughly examined. In intractable cases perineuritis is present, and the adhesions should be divided. Nerve-stretching should not be done as a routine treatment, but is sometimes of value.

External Popliteal Nerve

This is more often injured than any other nerve of the lower limb. It may suffer when bound up with the internal popliteal to form the great sciatic, or, after it has separated, above or below the point at which its lateral cutaneous branch is given off. Injury in the latter position is the more common.

Anatomical division of the nerve is rare, but it has occurred during tenotomy of the biceps tendon. It suffers most often from direct violence, owing to its exposed position on the neck of the fibula, and in association with fractures of the neck of the fibula, the nerve injury being primary, and caused by the injury producing the fracture. It is occasionally overstretched, and sometimes ruptured, during the forcible extension of a flexed and ankylosed knee. It is occasionally involved in cases due to occupations necessitating a crouching attitude.

Symptoms.—The foot is in the position of talipes equino-varus, and the tibialis anticus, all the extensors of the toes, and the peronei muscles are paralysed.

Deep sensibility is unaffected; this fact has caused diagnostic errors. The loss of sensibility which results from division of the nerve below the point at which its lateral cutaneous branch arises is only absolute on the dorsum of the foot and the lower third of the leg. But division above this branch produces a large area of loss of sensibility.

agnosis.—*Injury to the 5th lumbar root in the spinal canal,* the 5th anterior primary division as it crosses the brim of the will give rise to symptoms resembling those of division of ternal popliteal.

consideration of the nature of the accident will lead to the osis in most cases, but the symptoms also will point out the t seat. Injury to the 5th anterior root or anterior primary on usually leaves the tibialis anticus muscle unaffected; in an to the lumbo-sacral cord or external popliteal nerve this muscle alysed. An injury to the 5th anterior root leaves sensibility paired; if the posterior root is affected in addition, the loss of touch *is less extensive than the loss of sensibility to prick.*

reatment.—In addition to the usual treatment, foot-drop be prevented by a suitable splint, and later by a surgical boot light shoe.

INVOLVEMENT IN FRACTURES

ie division *is in most cases physiological, the nerve usually passing* en the fragments. In all cases of fracture of the upper end of ibula with involvement of this nerve, if there is any separation e fragments, primary operation should be undertaken, the nerve , and the fragments exposed and wired, or the small upper frag- may be completely removed, care being taken to injure the hment of the biceps as little as possible. If the nerve is found ured, it should be sutured. When the fragments are in close sition immediate operation is unnecessary; the usual treatment subcutaneous injury should be instituted. In old cases in which eaction of degeneration has developed, the damaged portion of ierve *must be excised, neurolysis is useless.*

INTERNAL POPLITEAL NERVE

njury to this nerve is uncommon; it has occurred during the ble straightening of a flexed and ankylosed knee.

'he calf muscles, the tibialis posticus, and the flexors of the toes paralysed.

'here is no loss of deep sensibility after complete division of this e, but epicritic and protopathic sensibility are lost over the sole ie foot.

ANTERIOR TIBIAL NERVE

'his *nerve is rarely injured alone,* on account of its deep position, occasionally it is pressed upon or lacerated in fractures of the a, and all the symptoms of irritative involvement may appear.

Anatomically, filaments of this nerve may be traced to the cleft tween the great and second toes, but it has here no exclusive supply.

I have on two occasions divided this nerve for therapeutic purposes and failed to produce any loss of sensibility in this situation.

TUMOURS OF NERVES

Tumours involving nerves are divided into two groups—the true, consisting of nerve-fibres and nerve-cells, and the false, in which the growth springs from the connective-tissue sheath of the nerve. The bulbs formed on the central ends of divided nerves have been considered by some as examples of "true," by others as "false" neuromas. Using the term "tumour" in its usually accepted significance, such swellings cannot be placed in this class any more than an excess of callus after fracture should be included among the tumours of bone.

TRUE NEUROMAS

According to Alexis Thomson, there are only five authenticated cases on record. *They are innocent tumours, and originate most commonly from the* abdominal sympathetic, less often in the subcutaneous tissues. They have no connexion with cases of neuro-fibromatosis

They have been met with up to the age of 30, and are unattended by symptoms which might indicate their nervous origin. They may be solitary or multiple, and vary in size from a pea to a child's head.

Diagnosis is impossible.

FALSE NEUROMAS

Under this heading conditions so diverse as a painful subcutaneous nodule and molluscum fibrosum are included The following classification, based on that given by Alexis Thomson in his exhaustive monograph on neuroma *and neuro-fibromatosis, is at the present time the most satisfactory:—*

CIRCUMSCRIBED { *Innocent:* Fibroma, myxoma, and cysts arising from them.
Malignant: Sarcoma.

DIFFUSE . . { *Inno* ... ised neuro fibroma.
tosum (pachydermatocele).
Malignant: Sarcoma arising in any of the above.

CIRCUMSCRIBED FALSE NEUROMAS

These are composed of fibrous or myxomatous tissue. They are, as a rule, solitary; although more than one may be present, there is no tendency to generalized disease.

These tumours are of slow growth, and rarely larger than a hazel-nut. They are well encapsuled, usually growing in the centre of the nerve with the nerve-fibres spread out around it *Cyst-formation is common*, and the cyst may contain blood.

... is small and originates in a terminal unnamed branch, ... e" (Wood). This ... nches in the lower ... in the upper, and ... e brachial plexus. ... n noticed between

They may be met with at any age, ... 20 and 40, and in women than in men.

A tender tumour is present in the course of a nerve—oval, well defined, movable laterally. The painful subcutaneous nodule is a small tender swelling immediately under the skin.

Pain on palpation usually radiates to the distribution of the nerve, and is occasionally spontaneous. Sensation and motion are rarely affected, except in long-standing cases with cyst-formation. If anæsthesia, muscular wasting, and paralysis are present, diffuse fibrosis due to irritation or to malignant tumour should be considered.

Fibromas sometimes spring from the sheath of the auditory nerve and [illegible] of intracranial tumour. [illegible] lling and its lateral, [illegible] clavicle may cause [illegible] vere sent to me as

[illegible] should be excised; in the larger tumours the nerve should be exposed above and below, its sheath divided longitudinally over the tumour, and the tumour carefully shelled out. In the rare instances where this is impossible the tumour should be excised and the continuity of the nerve re-established by one of the methods mentioned at p. 401.

MALIGNANT NEUROMAS

These are rare tumours: Alexis Thomson was able to collect 12 cases only, and the writer has recently had one under his care. These may be either spindle-celled, fibro-, or myo-sarcoma. They may be primary, or may result from malignant degeneration of an innocent tumour; the latter is uncommon. At first encapsuled, the cells of which the tumour is composed presently spread between the nerve-fibres and later invade the surrounding tissues.

Sarcoma is most common in males between the ages of 20 and 40.

The great sciatic and its branches are most often affected. Unlike the innocent tumours, they cause progressive interference with the functions of the nerve, and can be diagnosed on these grounds.

Treatment.—If they are seen early, wide resection should be carried out, a section of the ends of the nerve being made for microscopical examination during the course of the operation, to be certain that the incision is made above the infiltrated area. The continuity of the nerve should be restored by one of the methods described at p. 401. If the growth is adherent to surrounding parts, amputation should be performed.

Prognosis.—Recurrence has been the rule in the cases hitherto recorded. Only in two has life been prolonged beyond two years, the majority of the patients dying from internal metastases.

Diffuse False Neuromas—Neuro-Fibromatosis (Von Recklinghausen's Disease)

Under this heading a number of conditions are included which have one feature in common—a diffuse overgrowth of the connective tissue of the nerve. They may be divided into groups for purposes of description, but these groups run into one another, and transitional forms are met with.

1. *Generalized neuro-fibromatosis.*—In this condition not only are there multiple tumours resembling those described under Circumscribed Neuromas,

I have on two occasions divided this nerve for therapeutic purposes and failed to produce any loss of sensibility in this situation.

TUMOURS OF NERVES

Tumours involving nerves are divided into two groups—the true, consisting of nerve-fibres and nerve-cells, and the false, in which the growth springs from the connective-tissue sheath of the nerve. The bulbs formed on the central ends of divided nerves have been considered by some as examples of "true," by others as "false" neuromas Using the term "tumour" in its usually accepted significance, such swellings cannot be placed in this class any more than an excess of callus after fracture should be included among the tumours of bone.

TRUE NEUROMAS

According to Alexis Thomson, there are only five authenticated cases on record. They are innocent tumours, and originate most commonly from the abdominal sympathetic, less often in the subcutaneous tissues. They have no connexion with cases of neuro-fibromatosis.

They have been met with up to the age of 30, and are unattended by symptoms which might indicate their nervous origin. They may be solitary or multiple, and vary in size from a pea to a child's head.

Diagnosis is impossible.

FALSE NEUROMAS

Under this heading conditions so diverse as a painful subcutaneous nodule and molluscum fibrosum are included The following classification, based on that given by Alexis Thomson in his exhaustive monograph on neuroma and neuro-fibromatosis, is at the present time the most satisfactory:—

CIRCUMSCRIBED { *Innocent*: Fibroma, myxoma, and cysts arising from them.
Malignant: Sarcoma.

DIFFUSE . . { *Inno* [illegible] ...lized neuro-fibroma-
[illegible]
tosum (pachydermatocele).
Malignant: Sarcoma arising in any of the above.

Circumscribed False Neuromas

These are composed of fibrous or myxomatous tissue. They are, as a rule, solitary; although more than one may be present, there is no tendency to generalized disease.

These tumours are of slow growth, and rarely larger than a *hazel-nut*. They are well encapsuled, usually growing in the centre of the nerve with the nerve-fibres spread out around it Cyst-formation is common, and the cyst may contain blood.

When the tumour is small and originates in a terminal unnamed branch, it was at one time called a "painful subcutaneous tubercle" (Wood). This latter variety is undoubtedly more common on nerve branches in the lower [illegible] common in the upper, and [illegible] ...us. [illegible] ...een

20 and 40, and in women [illegible]

A tender tumour is present in the course of a nerve—oval, well defined, movable laterally. The painful subcutaneous nodule is a small tender swelling immediately under the skin.

Pain on palpation usually radiates to the distribution of the nerve, and is occasionally spontaneous. Sensation and motion are rarely affected, except in long-standing cases with cyst-formation. If anæsthesia, muscular wasting, and paralysis are present, diffuse fibrosis due to irritation or to malignant tumour should be considered.

Fibromas sometimes spring from the sheath of the auditory nerve and give rise to symptoms of intracranial tumour.

D[illegible] lling and its lateral, but [illegible]

A [illegible] clavicle may cause cons[illegible] vere sent to me as "malignant glands of neck."

Treatment.—The painful subcutaneous nodule should be excised; in the larger tumours the nerve should be exposed above and below, its sheath divided longitudinally over the tumour, and the tumour carefully shelled out. In the rare instances where this is impossible the tumour should be excised and the continuity of the nerve re-established by one of the methods mentioned at p. 401.

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Under this heading a number of conditions are included which have one feature in common—a diffuse overgrowth of the connective tissue of the nerve. They may be divided into groups for purposes of description, but these groups run into one another, and transitional forms are met with.

1. *Generalized neuro-fibromatosis.*—In this condition not only are there multiple tumours resembling those described under Circumscribed Neuromas,

but the nerves are diffusely thickened. In some patients the tumour-formation is the more prominent feature, in others the generalized thickening. The peripheral nerves are invariably affected, and the posterior root ganglia are sometimes involved, and the anterior and posterior roots, particularly of the cauda equina. The cranial nerves are affected in two-thirds of the cases, the vagus suffering most often, then the 5th and 12th. The same change may be seen in the nerves in the substance of the muscles, and the terminal filaments of the cutaneous nerves are often involved. In most cases the sympathetic cord is extensively affected.

2. *The plexiform neuro-fibroma.*—In this condition the fibromatosis is confined to the distribution of a nerve or nerve plexus. As in the generalized form, the thickening is due to increase of fibrous tissue. It is composed of a mass of nodular and tortuous nerve-fibres bound together by loose fibrous tissue. It may be met with affecting any portion of the cerebro-spinal or sympathetic nervous system, but is most frequently met with in the distribution of the trigeminal and superficial cervical nerves.

3. *Cutaneous neuro-fibromas* (molluscum fibrosum).—The chief characteristic of this condition, the nature of which was first elucidated by von Recklinghausen in 1882, is the presence of numerous soft tumours generalized over the body, with the exception of the palms of the hands and the soles of the feet. These vary in size, are usually pedunculated, and are covered with smooth skin. In addition, tumours are present on the nerve trunks in many cases. Pigmentation of the skin, usually on the trunk, exists in about half the cases. There may be gradual loss of intellectual power and marked despondency. The disease is usually of congenital origin.

4. [illegible] Virchow from other [illegible] ere is a diffuse overgr[illegible] portion of the body. In the lower limb it resembles other forms of elephantiasis. The disease is congenital, and starts as a pigmented patch or in a molluscum fibrosum. The special feature of the condition is the spread of the fibromatosis from the connective tissue of the cutaneous nerves to the tissues surrounding them.

Symptoms.—An extensive neuro-fibromatosis may be present without giving rise to any symptoms. *It manifests itself by the presence of tumours on the trunk and extremities.* These tumours are, as a rule, quite painless, [illegible] to

[illegible]

cords may be produced by the tumour or nerve-roots, [illegible] cauda equina. This gives rise to the usual symptoms (*see* p. 426). So long as the disease is stationary the general health of the patient is not interfered with. When it is progressive, loss of weight and anæmia may occur. The patient may become apathetic, and death occur from exhaustion or from sarcomatous degeneration in one of the tumours.

Treatment.—*In* all cases of neuro-fibromatosis surgical interference should be limited to removal of tumours which are painful or interfering with the well-being of the patient in other ways. It has been repeatedly observed that operation has been followed by increase in the size and number of the tumours.

SARCOMA

Sarcomatous degeneration may occur in any of the tumours met with in generalized neuro-fibromatosis. As first pointed out by Garré, this form

of sarcoma differs from that which develops in a normal nerve trunk. It is characterized by the rapid growth of a tumour which has been in existence for years, rarely involves the surrounding tissues unless recurring after removal, and internal metastases are late.

Treatment.—Amputation well above the sarcoma is the only treatment in the cases of the limbs; free excision is demanded elsewhere.

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THE SCALP, SKULL, AND BRAIN

BY WILFRED TROTTER, M.S., F.R.C.S.

Surgical anatomy.—The integuments over the vault of the skull, like those of the palm of the hand and the sole of the foot, are peculiar in being firmly united to an extensive and well-marked aponeurotic membrane. This subcutaneous fibrous sheet, unlike the palmar and plantar fasciæ, is for the most part deep to the vessels and nerves, and freely movable on the underlying parts.

The **skin of the scalp** is thick and tough, it contains thickly set and deeply penetrating hair bulbs, with correspondingly large sebaceous glands which frequently give rise to cysts.

The **subcutaneous fat** is relatively small in amount, and is much intersected by a network of strong fibrous tissue, everywhere binding the skin firmly to the epicranial aponeurosis. In this layer lie the principal vessels of the scalp; their external coats are united with the fibrous subcutaneous tissue, so that when an artery is divided it does not retract, and therefore bleeds freely and persistently The subcutaneous fat of the scalp is somewhat thicker in fat subjects than in thin, but does not differ in the two classes to anything like the same degree as elsewhere It is of fairly uniform thickness all over the cranium, but gradually increases in thickness towards the posterior part and is always thickest over the occiput. Other things being equal, cuts are therefore less likely to reach the bone over the hinder part of the skull than over the vertex. The firmness of this tissue prevents hæmatomas in it from reaching any considerable size, as the blood-pressure is not sufficiently great in itself to strip up the skin from the aponeurosis. Cuts in the scalp not penetrating the aponeurosis have no tendency to gape unless they are accompanied by much bruising of their edges. In bald persons the scalp becomes markedly thinned and its vessels much reduced in size.

The **epicranial aponeurosis** forms with the occipitales and frontales muscles a continuous fibro-muscular sheet—the occipito-frontalis, extending from the level of the external occipital protuberance forwards to the level of the eyebrows The exact attachments of this layer are of practical importance, though frequently the subject of some misapprehension. *Posteriorly each occipitalis muscle, separated from its fellow by* a considerable interval, arises from the outer part (one-half or thereabouts) of the corresponding superior curved line of the occipital bone. Between the muscles of the two sides the aponeurosis itself is attached to the bone at about the same level. *Laterally* the aponeurosis thins off below the level of the temporal crest and blends, but at no precise line, with the underlying temporal fascia. *Anteriorly* the frontales muscles arising from the aponeurosis close to the middle line extend downwards,

and their fibres, interlacing with those of the overlying orbiculares palpebrarum, end in the skin in the region of the eyebrow. Near the middle line a few fibres may become attached to the bone and the aponeurosis of the nose. It follows from these anatomical facts that collections of blood under the occipito-frontalis may extend downwards in front into the upper eyelids, coming to be situated there between the orbicularis in front and the tarsal plate with the palpebral fascia behind. Cuts of the scalp penetrating the occipito-frontalis across the direction of its fibres tend to gape freely.

The **areolar layer** separating the occipito-frontalis from the pericranium consists of very loose cellular tissue—which allows of free movement of the overlying parts on the skull. It contains no vessels of any considerable size, except the parietal emissary veins in their passage to the subcutaneous tissue, and the supra-orbital and frontal vessels between the orbital margin and a level 2 or 3 in. higher up, where they penetrate the occipito-frontalis and become superficial.

Through this areolar layer occurs the separation in the scalping accidents not uncommon in women employed amidst machinery in motion When hæmorrhage occurs in this layer the blood is apt to extend unchecked throughout the subepicranial region and to form very large collections.

The **pericranium** *or external periosteum of the skull is in the* adult a thin, fibrous membrane firmly attached at the sutures but less so to the bones, of slight vascularity and low osteogenetic power. Detachment of it from the skull over large areas, if not accompanied by sepsis, produces no effect on the nutrition of the bones, as the blood supply of the latter comes almost exclusively from the diploë. In the young child the pericranium is more firmly adherent to the bone, more vascular, and has considerable osteogenetic power still surviving; that is to say, it possesses many of the characters of the membrane in which the cranial bones were developed, and of which it is obviously a remnant.

The **cranial bones** normally exhibit the structure of two compact tables separated by a cancellous and vascular layer, the *diploë*. The latter varies somewhat in thickness from place to place in the same skull; it is less developed in the infant and the aged than in the adult, and in conditions of thinning of the skull, from whatever cause, is the structure which disappears first. The diploë is well supplied with blood both from extracranial and intracranial vessels, and its veins communicate very freely with those of the scalp and *the sinuses of the dura mater, especially* the superior longitudinal, the lateral, and the cavernous. Into the last-named opens the large spheno-parietal sinus, which drains the fronto-parietal region of the skull These vascular connexions make the diploë the starting-point of practically all infective lesions of the cranial vault. The vascularity of the diploë may be increased *locally* in the neighbourhood of cranial tumours, and *generally* by longstanding high intracranial tension. In the latter condition the diploic veins tend to become much enlarged and may show very conspicuously in radiographs of the skull.

The form of the skull, as explored by inspection and palpation, should always be carefully studied in head cases It is therefore of importance that the surgeon should be familiar with variations within normal limits No very thorough examination can be made unless the head has been shaved.

The upper angle of the occipital bone always projects above the parietal bones, between which it fits. Sometimes the apex is so prominent as to suggest the presence of disease The external occipital protuberance varies

greatly in prominence, and sometimes reaches a projection of $\frac{1}{2}$–$\frac{3}{4}$ in. above the surrounding bone. The crescentic area of bone above the superior curved line and below the highest curved line is sometimes sufficiently pronounced to be distinctly palpable (torus occipitalis transversus). The squamous part of the temporal commonly is more prominent than the parietal bone above it. The temporal crest varies considerably, and may be palpable throughout its length.

The *sutures* of the normal adult skull cannot be felt as such. In premature synostosis they are sometimes marked by a ridge. Occasionally in children's skulls the remains of the metopic suture can be felt as a groove.

Large veins in the scalp are less resistant than the surrounding parts, and therefore frequently give the impression that they occupy considerable grooves in the skull—a situation which in fact they never occupy.

In opening the skull it is important, if possible, to remove the first disc of bone from a part which is of uniform thickness, otherwise the dura may be lacerated. The cerebellar fossa is itself very thin but is surrounded by thick ridges of bone, and here the danger of injuring the dura is considerable. In trephining low down in the temporal fossa the same trouble may be caused by the irregularity of the inner table from the cerebral impressions on it.

Variations in texture.—The density of the cranial bones varies through a wide range in different subjects. A very dense ivory-like texture is fairly common and may seriously increase the technical difficulty of operations on the skull. An unusually soft structure with wide diploë and little compact tissue is less common though not rare. Bone of this consistence may occur in irregular patches which have a dusky purplish colour contrasting with the yellowish pink of surrounding parts. As far as is known, this condition has no pathological significance.

Vessels of the scalp.—These are large, numerous, and freely anastomosing, so that flaps can be cut in practically any direction without fear of causing sloughing. The relation of the vessels to the various layers has already been mentioned.

The *arteries* come from two sources, the internal carotid (frontal and supra-orbital through the ophthalmic) and the external carotid (superficial temporal, posterior auricular, occipital). The freedom of the anastomosis in the scalp is of value in reinforcing the cerebral circulation through the orbit after ligature of the common or internal carotid artery.

The *veins* may be grouped roughly but conveniently in three sets, according to the channels they enter after leaving the scalp:

1. { Frontal, Supra-orbital } Ophthalmic. Cavernous sinus.
2. { Posterior auricular, Superficial temporal } External jugular and common facial.
3. Occipital. Deep cervical vein.

All of them communicate with the diploic veins, and thus indirectly with the sinuses, while most have also direct communication with the sinuses, the two most constant channels being the parietal emissary vein (occipital from longitudinal sinus) and the mastoid emissary vein (posterior auricular from lateral sinus).

Nerves of the scalp.—The *sensory* supply of the scalp comes from nerves of three classes—a cranial nerve, the anterior primary divisions, the posterior primary divisions. A line drawn transversely across

the cranial vault from one external auditory meatus to the other may be regarded as corresponding with sufficient accuracy for practical purposes with the posterior limit of the cutaneous distribution of the trigeminal nerve. Behind this line the skin of the occiput is supplied by the great occipital [illegible] division of second cervical). In and near the middle line [illegible] meet, but laterally they are [illegible] small occipital and the great [illegible] and third cervical). [illegible] skull the distribution of the sensory nerves should if possible be taken into account, and the incisions kept as near as may be to the boundary zones of adjacent areas

There is but one *motor* nerve in the scalp which is of any practical importance, and that is the branch of the facial which supplies the frontalis and the corrugator supercilii. This nerve crosses the zygoma obliquely upwards and forwards about ½–¾ in. behind the external angular process, and is therefore liable to be cut in the incision for the removal of the Gasserian ganglion. The resulting smoothness of the forehead and drooping of the eyebrow on the same side are sometimes quite conspicuous.

Dura mater.—The cranial dura mater consists of a strong fibrous membrane which, where it lies on the bones, is blended with the internal periosteum to form one structure. This is always firmly united with the bones over the base of the skull. To the bones of the vault the union is almost equally firm in the infant, but much less so in the adult. In consequence, fractures of the base are practically always accompanied by tearing of the dura, while fractures of the vault are complicated in this way frequently in children, rarely in adults.

The **septa of the dura mater** are of great practical significance in the surgery of the brain. The most important of them is undoubtedly the *tentorium*. This prolongs the floor of the middle fossa backwards to the occipital bone as an extremely resistant membrane, and in this way divides the intracranial cavity into two chambers—the superior or cerebral, and the inferior or cerebellar—communicating only by the opening in the tentorium, which is occupied and nearly filled by the midbrain. A comparatively slight displacement downwards of the wedge-shaped midbrain will block this foramen completely, and so prevent an increase of intracranial tension in the superior chamber from being readily or completely transmitted to the vital structures in the inferior.

The *falx cerebri*, forming a partial septum between the two halves of the superior chamber, may similarly be converted into a complete partition by impaction in it of a displaced hemisphere. In such cases bilateral trephining will show high intracranial tension on the side of the lesion (usually a hæmorrhage), with normal or, more likely, comparatively little elevated tension on the other.

The *falx cerebelli* is probably not sufficiently marked to render possible a similar pathological separation of the halves of the inferior chamber. The point, however, is of little importance, since in circumstances in which it could occur the pressure on the bulb would be so great as to be rapidly fatal.

Sinuses of the dura mater.—The sinuses lying in contact with the skull are situated between the periosteal and supporting layers of the dura, so that their cerebral walls are thicker and stronger than their cranial walls Laceration of a sinus on its cranial aspect is therefore a complication of fracture of the skull not particularly uncommon; when met with in the course of an operation it may cause severe and even dan-

gerous hæmorrhage. Such a lesion of the dural sinuses or veins may lead to the formation of an extradural hæmatoma, with pressure on the brain. Laceration of a sinus on its cerebral aspect or transverse tearing through the whole sinus is comparatively rare even in children and produces serious effects. Another practical consequence of the thinness of the outer wall of the sinuses is that an extradural collection of pus over a sinus is extremely likely to produce phlebitis and thrombosis within it.

The *superior longitudinal sinus*, extending from the crista galli in front to the internal occipital protuberance behind, is a well-marked channel triangular in section and rapidly increasing in size from before backwards. Its blood comes principally from the superior cerebral veins which drain the upper part of the hemispheres on both mesial and lateral surfaces. It receives also many small veins from the diploë. The communication with the nasal veins anteriorly which is described by anatomists cannot be of any significant size or frequency, since thrombosis of the sinus directly secondary to nasal disease is very uncommon.

The cerebral veins are directed obliquely upwards and forwards towards the sinus, so that if they were to enter the sinus direct the current in them would be contrary in direction to that in it. This, however, they for the most part do not do. Extending outwards from the sinus for as much as an inch or more between the layers of the dura are large pool-like spaces, the parasinoidal sinuses or lacunæ laterales These it is which receive the cerebral veins. Through the cerebral walls of these lacunæ the Pacchionian bodies project and in the adult extend through them and produce the well-known depressions in the skull. The Pacchionian bodies, and therefore the lacunæ, are extremely liable to be torn when the bone overlying them is removed, hence it is desirable at operations to avoid carrying the removal of bone mesially within an inch of the middle line. When the bone in this region has to be removed, a good deal of bleeding almost always occurs, and some little time and trouble may be needed to stop it. Again, when the dura is reflected within the same distance of the middle line, not only may troublesome bleeding occur from the edges of the incision, but the cerebral veins (which enter the dura for some considerable distance away from the longitudinal sinus) are extremely apt to be torn.

A cerebral vein has a short free course between the point where it leaves the surface of the hemisphere and the point where it enters the dura on its way to a lacuna lateralis. This segment of the vein has its peripheral end fixed by the dura, while its central end shares the mobility of the hemisphere; for this reason it is especially liable to be torn.

The *lateral sinus* is a more sharply defined channel than the superior longitudinal. It extends from the internal occipital protuberance in a flat arch to the back of the petrous bone, and in a marked C-shaped bend from here to the jugular foramen. The junction of the superior petrosal sinus marks the passing of the arched into the sigmoid part. As a rule, the right lateral sinus is the continuation of the superior longitudinal, and so receives blood from the surface of both hemispheres, while the left is the continuation of the straight sinus, and so receives blood from the choroid plexuses and central ganglia. When this arrangement obtains, the lateral sinus of the right side is considerably larger than that of the left, as is the corresponding internal jugular vein. The two lateral sinuses communicate at the internal occipital protuberance, but the communication is not usually large. In about 3 per cent. of bodies the left internal jugular is so small that it could scarcely provide an adequate outlet for the intracranial venous circulation after ligature of the vein of the right

side. *In such cases this operation might be expected to cause symptoms* of intracranial venous engorgement. Many instances are recorded of this occurrence. Small lateral tributaries of the sinus enter it above from the occipital lobe in the arched part, and from the cerebellum below in both the arched and sigmoid parts. They give rise to some bleeding in operations on these parts of the brain when it is necessary to explore the upper or lower surface of the tentorium, but such bleeding is rarely troublesome *except in the presence of high intracranial tension.*

The *cavernous sinus* has neither the clear straightforward channel of the lateral sinus, nor the tributary pools and backwaters of the superior longitudinal; its cavity is cut up by interlacing trabeculæ into a sponge-like structure, and is traversed by a large artery (the internal carotid)

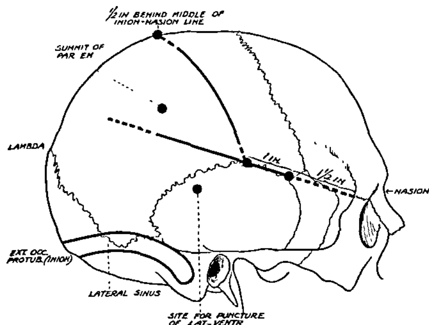


FIG. 733.—Relation of K. Rolandic and Sylvian fissures to the surface of the skull. The solid black lines indicate the position of the fissures.

and an important nerve (the abducens) This peculiarity of its structure probably increases greatly the liability of the sinus to thrombosis; this liability must be regarded as considerable when we remember how much rarer are spreading *foci of suppuration in its immediate neighbourhood* than in the neighbourhood of the lateral or superior longitudinal. The multitudinous tributaries and effluents of the cavernous sinus render it liable to infection from widely different sources. The enumeration of its connexions may, however, be left until phlebitis and thrombosis are dealt with.

Cranio-cerebral topography (Fig. 733).—The exact determination of the relation of cerebral sulci and convolutions to the surface of the scalp and skull has not such critical importance as was formerly ascribed to it. It is now recognized that in dealing with focal lesions of

the brain a large opening in the skull is almost always necessary, so that minute exactitude in "placing" it is superfluous Again, *the relations of* the brain to the surface are sufficiently variable to render the finding of any given gyrus or sulcus a very precarious matter if external measurement alone is relied on. The surgeon should, however, be *able to determine the* position of the fissures of Rolando and Sylvius with fair accuracy, and will generally be able to recognize them when they are exposed if the opening in the skull is large. *It must be remembered that the fissure of Rolando* may not be recognizable even when a considerable length of it is exposed. In such cases only electrical stimulation of the cortex can be decisive, and *it should certainly* be used if exact orientation is necessary.

The **Sylvian fissure** (posterior limb) corresponds with the highest part of the squamous suture in the adult. A line drawn from the fronto-malar junction (which is palpable through the skin) to the lower part of the parietal eminence (about ¾ in. below the summit) will mark the course of the fissure. A point upon the line 1½ in. from the fronto-malar junction will indicate the meeting-place of the posterior limb with the anterior and ascending limbs.

The **Rolandic fissure** is of great importance, as it forms the posterior boundary of the motor area of the cortex. It runs downwards and forwards at an angle of about 70° with the middle line Its course is *tortuous, being marked by two prominent curves, the lower of which* (inferior genu) projects forwards just below the middle of the fissure.

To mark out the fissure two points are necessary, an upper and a *lower. The upper is in the middle line of the skull ½ in. behind the mid*point between the root of the nose (nasion) and the external occipital protuberance (inion). The lower is on the line already described as indicating *the Sylvian fissure, and 2½ in. from the fronto-malar junction. The line* joining these two points is a little longer than the fissure above and below, and the inferior genu projects somewhat in front of it.

The fissure lies beneath the anterior part of the parietal bone, its upper end 1¾ in. and its lower end 1¼ in. behind the coronal suture. The inferior genu is close to the temporal line of the parietal bone, so that the arm area of the precentral gyrus is just above that line.

Numerous other methods of marking out the Rolandic and Sylvian fissures have been invented. They are for the most part much more complex and probably not more accurate than the ones described above, which are, with slight modification, those of Thane and Godlee. Another *plan, commonly adopted,* and sufficiently accurate, of locating the fissure of Rolando consists in finding the upper point as above; then in drawing a line 3½ in. long downwards and forwards at an angle of 67½° (i.e. three-fourths of the rectangular corner of a sheet of paper).

Puncture of the lateral ventricle (Fig. 733) may be done at various points. The ventricle can be reached in the region of the conflu*ence of the posterior and descending* horns by a puncture 1½ in. above the external auditory meatus and ½-1 in. behind it. The cavity is entered about 2 in. from the surface.

Middle meningeal artery.—*A convenient* place at which to begin the opening of the skull for the exposure of the anterior branch of this artery is at a point 1½ in. above the zygoma and 1½ in. behind the external angular process of the *frontal bone. The posterior* branch, roughly, runs horizontally about 1 in. above the level of the middle of the external auditory meatus.

The **sigmoid bend** of the **lateral sinus** crosses Reid's base line at a point $\frac{3}{4}$ in. behind the middle of the external auditory meatus. The **horizontal portion** runs in a curve about $\frac{1}{4}$ in. above Reid's base line from the sigmoid bend to the region of the inion. **Reid's base line** is a line drawn from the lower orbital margin through the middle of the external auditory meatus and thence produced backwards.

INJURIES OF THE SCALP

CONTUSIONS: HÆMATOMA

Bruises of the scalp have considerable importance from the different situations in which extravasation may occur, and from certain difficulties in diagnosis to which they may—perhaps unnecessarily—give rise.

Subcutaneous Hæmatoma

Extravasations of blood in the subcutaneous tissue are, on account of the density and firmness of the latter, concentrically distributed about the point struck, and have no tendency to spread in any given direction; they are therefore circular in outline, and never of any great superficial extent. At the actual spot on which a severe localized blow is received the damage is sufficient to detach the skin from the underlying aponeurosis, and so to lead to an actual collection of fluid blood there. Concentrically distributed about this will be a zone in which the damage, being less severe, has led merely to the infiltration of the subcutaneous tissue with blood. Therefore clinically the hæmatoma presents a more or less hemispherical swelling, the centre of which is fluid and yielding, while the peripheral part is hard. This soft area surrounded by a hard margin suggests very strongly the signs which a depressed fracture of the skull might be expected to present, and has very often been mistaken for such. It is commonly said that if firm pressure be made on the centre of the swelling the finger will come down upon the solid underlying skull. The difficulties in applying this theoretically excellent test are that such swellings are very tender, so that it may not be possible to exercise adequate pressure; that the surgeon naturally feels some diffidence in pressing firmly upon what *may* be a depressed fragment of bone; and that when the firm skull is attained by the finger-tip there may be great uncertainty as to whether it is at the same level as the surrounding normal skull.

A second and much more valuable sign is that the hard surrounding margin which simulates the edge of a gap in the skull pits when firm pressure is made on it, thus showing that it consists not of bone but indurated soft parts. Finally, the whole mass, soft centre and indurated margin as well, may be demonstrably movable

upon the skull. The movement, however, is comparatively slight, and not as a rule very convincing. But in spite of these tests the suggestion of the presence of a depressed fracture may be irresistibly strong, and I have known a surgeon of experience not only insist on operating in such a case, but proceed to remove a length of the *coronal suture* under the impression that this was the fracture which he was convinced must be there.

The correct diagnosis of these injuries with any degree of confidence would seem to be a matter of great difficulty were it not for the fact that the supposed dilemma dates from a time when simple fractures of the skull, depressed or otherwise, were operated on very rarely, or not at all. Hence there could have been very few opportunities of correcting the diagnosis by actual inspection of the skull, especially if the majority of the cases which were supposed to be depressed fractures actually were merely hæmatomas, since practically none of these would develop complications needing operation later. Thus it could easily come to be believed that there was a class of non-compound depressed fractures in which a circular disc of bone was neatly detached from the skull and driven in, and that these gave signs resembling those of a hæmatoma.

When, however, we ask ourselves, with the guidance of modern operative experience, whether such a class does exist, we are compelled to answer that fractures of this character, if they occur at all, are of the very greatest rarity. The only *non-compound* depressed fracture that is at all common is the pond-shaped depression of infants, and in the diagnosis of this there is scarcely ever any difficulty. The solution of the problem would seem, then, to consist in the recognition of the fact that in the adult a depressed fracture without a wound of the scalp is extremely unlikely to occur, and that any supposed case of the kind must be looked upon with great suspicion. However, as *it is an infinitely more serious mistake to* leave a depressed fracture without operation than to explore a simple hæmatoma unnecessarily, should the surgeon still have doubts in a given case, after weighing the considerations just discussed, there can be no question whatever that it is a plain duty to operate.

Subepicranial Hæmatoma

Extravasations beneath the aponeurosis, when typically developed, extend from the superior curved line behind, over the whole cranial vault, and down into the upper eyelids in front. The latter are then bulged downwards and darkly stained in a very characteristic way, while the lower lids remain normal. Laterally the swelling terminates on each side somewhere between the temporal crest and the zygoma. The head is covered by a huge bag of fluid which

fluctuates freely. The hæmatoma does not always reach the full extent of these limits, but may be arrested after extending over a considerable part. In such cases the line at which it has ceased to extend will have the characters previously described as shown by the edges of a subcutaneous hæmatoma, that is, an indurated margin which pits when firm pressure is made over it. The lateral margins of the swelling over the temporal regions usually show the same characters.

Causation.—These hæmatomas are caused by blows on the head not obviously different from those which produce either of the other forms. Why the effect of apparently similar accidents should be to produce one type of extravasation at one time, and another type at another time, is not clearly known. From what has been said under Surgical Anatomy it might be expected that blows on the frontal region would be particularly likely to produce the subepicranial form, since it is here only that large vessels are found beneath the aponeurosis. So far as I am aware, however, this has not been shown to be the case.

An important form of this extravasation is due not to local bleeding from the subepicranial vessels, but to blood escaping through a fracture of the skull from a subdural or possibly extradural hæmorrhage In such a case the hæmatoma follows upon a severe injury, and there may at first even for some days be no symptoms of pressure on the brain, since the blood can escape freely into the subepicranial region. When, however, this becomes tensely filled, compression symptoms appear. This "safety-valve hæmatoma" occurs principally in children, in whom, as already mentioned, laceration of pericranium and dura is a common complication of cranial fracture.

Course.—The ordinary subepicranial hæmatoma of full extent usually increases progressively for several days until it becomes quite tense, then ceases to enlarge and remains stationary for some days longer, and finally is slowly absorbed in the course of some weeks. However tense it may become, there is very little likelihood of its ever causing sloughing of the overlying scalp through stretching and pressure on the vessels.

Suppuration rarely occurs, and is very much more likely to be suspected than to be present. The absorption of such a large collection of blood is usually accompanied by considerable constitutional symptoms—general discomfort, fever, even delirium—and often suggestive local ones as well, such as œdema of the surrounding soft parts and increasing tenderness.

Diagnosis.—The completely developed hæmatoma is quite characteristic in its extent and form. Some variability in its lateral limits may be expected The incompletely developed form, although

not fully occupying the subepicranial region, extends throughout enough of it to be obviously neither subcutaneous nor subpericranial. For example, it may reach from the upper eyelids in front to an oblique or irregular posterior margin in the parietal region. Such swelling clearly cannot be a hæmatoma of either of these kinds.

In the form complicating fracture of the skull there is nothing necessarily in the swelling to show how it has arisen. Suspicion should always be aroused when the causal accident has been a severe one and the patient is a young child.

Treatment.—Cases left entirely untreated usually run their course to complete recovery, though the process may be accompanied by considerable discomfort to the patient.

Nothing short of operation can be done to check the hæmorrhage. The traditional tight bandaging and ice-bag probably have no effect except in increasing the patient's discomfort. The only urgent indication for incision is suppuration. As already mentioned, this is rare, and very likely to be suspected when it is not present. Nevertheless, the consequences of it are so serious that the surgeon should not hesitate unduly in the presence of suspicious signs. Although the cases usually progress to recovery, it often happens during the persistence of the swelling that there is great tenderness and discomfort, the child's sleep being much disturbed by the pain caused when the head is laid on a pillow. In these circumstances it is best to cut the trouble short by making an incision and evacuating the hæmatoma. The aseptic precautions for such an operation cannot be considered adequate unless the head is shaved and the whole scalp carefully prepared.

Subpericranial Hæmatoma (Cephalhæmatoma)

Hæmorrhage beneath the external periosteum of the skull is limited to the bone over which it originates by the attachment of this membrane to the sutures. This gives to the swelling a characteristic form As with the other kinds of hæmatoma of the scalp, the swelling has from the first a fluid centre with a hard margin, which, however, pits when firmly pressed on. This margin slopes away peripherally, but ends abruptly towards the centre. The prominent part of the swelling does not, therefore, extend to the edges of the bone on which it is seated, but is of rounded outline, being continued to the adjacent sutures by the sloping indurated border. Again, the hæmatoma does not necessarily, even with its sloping margin, occupy *the whole of the bone on which it is situated*, but may extend to one or two only of the adjacent sutures. The invariable rule, however, is that none of the sutures limiting the given bone *will be overstepped*.

Causation.—In spite of the fact that the pericranium is more firmly adherent to the bone in the child than in the adult, hæmorrhage under it is much commoner in the former than in the latter. This is no doubt to be explained by the relatively great vascularity of the cranial periosteum in childhood. The condition is frequently noticed soon after birth, and then, no doubt, is due to injury received during passage of the head through the maternal pelvis, or possibly to instrumental delivery. In early childhood it is a fairly common consequence of blows on the head. As the vascularity of the pericranium diminishes with advancing years cephalhæmatoma becomes less and less frequent.

Course.—As a rule, a cephalhæmatoma will be absorbed in the course of a few weeks, and in a majority of cases the absorption proceeds uninterruptedly. As the condition occurs chiefly at an age when the osteogenetic power of the pericranium is still fairly active, there is usually time during the process for a little new bone to be formed in the margin of the swelling. Therefore not uncommonly a low, narrow ridge of new bone marks the outline of the former swelling for some considerable time after the extravasated blood has disappeared.

The most frequent complications of the process of recovery are —in the order of their frequency—delayed absorption, suppuration, excessive ossification. By *delayed absorption* is meant a condition in which the swelling remains tense and becomes increasingly tender, causing restlessness, irritability, and much disturbance of sleep. *Suppuration* is not very common. It may not occur until the swelling has been present for a week or more. In addition to the symptoms just enumerated, œdema of the scalp appears over and around the swelling, and the latter becomes less distinct in outline and more brawny and tenser in consistence. *Excessive ossification* is a rare complication. New bone is formed from the displaced periosteum, first at the periphery only, and then spreading in over the swelling until this is roofed in by a thin layer more or less completely. It is very unusual for it to be quite complete over the whole swelling, a soft area generally remaining palpable over the summit. Bosses of bone formed in this way may remain evident for some years; it is probable, however, that they are ultimately moulded away, though so far as I am aware the remote history of these very rare cases is not known.

Diagnosis.—A cephalhæmatoma may simulate a depression in the skull even more closely than does a subcutaneous hæmatoma, and the remarks made upon the diagnosis of the latter apply in this connexion. An added feature of difficulty in the case of the cephalhæmatoma is that this is immovably fixed to the skull.

Cephalhydrocele is defined as a subpericranial collection of cerebro-spinal fluid communicating with the subdural space through a fissure in the bone and dura, and occurring in children as a result of injury. According to established tradition, it should be considered in the differential diagnosis of cephalhæmatoma. Such a clinical and pathological entity, if it exists at all, must be exceedingly rare, and certainly rarer than the ventricular cysts which no doubt have usually been mistaken for it. *Any subpericranial collection of cerebro-spinal fluid in communication with the cranial cavity would show variations of tension in correspondence with the intracranial pressure, and thus be distinguishable from cephalhæmatoma.*

An ossified cephalhæmatoma might simulate leontiasis ossea or a tumour of the skull, but would be distinguishable in a skiagram and by palpation if, as is likely, ossification is incomplete over the summit of the swelling.

Treatment.—When absorption is delayed and the swelling is causing the patient discomfort it should be tapped or, perhaps better., incised. In no case should this be done without the use of a general anæsthetic, especially in infants, otherwise disinfection of the skin is likely to be imperfect and injury may be inflicted on the delicate cranial bones or even the fontanelles. Suppuration, if suspected, must be met by early incision. The surgeon will probably find that sooner or later he incises a hæmatoma suspecting suppuration but not finding it. This, though somewhat more energetic treatment than the case demands, effects a rapid and complete cure. The opposite mistake of leaving unopened a collection of pus in contact *with the skull is infinitely more serious* *If excessive ossification* is found to be occurring, the swelling should be incised to prevent the ugly deformity of a more or less persistent boss of bone on the skull.

WOUNDS OF THE SCALP

Incised wounds made with cutting instruments are not common in civil practice and present no special characters. Cuts with glass or crockery are frequent, and may be the result of carriage accidents of various kinds, or of the use of various utensils as weapons. The importance of these injuries is that the instrument of them usually smashes against *the skull and fills the wound with fragments.*

Owing to its mobility on the underlying hard skull, the scalp may be split by blows with blunt objects or by falls on hard substances, with the result that a lesion *closely resembling a cut may* be produced. As a general rule, however, wounds caused by blunt objects are much lacerated and contused; in the case of machinery and street accidents they have much dirt ground into them. *However*

much laceration may be present, primary sloughing of the scalp rarely occurs, because the blood supply is so free and because most severe injuries involve the epicranial aponeurosis, so that such detachment as occurs is below this layer, and the flaps which are raised carry with them the vessels. This is most strikingly seen in the scalping accidents met with by women working amidst machinery. These usually occur through the hair being caught between a fly-wheel and a belt running on it. Thus the whole scalp may be torn completely away, or be merely turned off as a large flap. Such flaps usually retain their vitality through the greater part of their extent.

Diagnosis.—Diagnosis of the *cause* of scalp wounds is sometimes of medico-legal importance. Apart from the fact that blows with blunt objects and falls occasionally cause wounds closely resembling those made by a sharp-edged instrument, there is nothing to found a conclusion upon that need be specifically indicated here.

The diagnosis of the *extent* of a scalp wound is always important, but should never be attempted until the surrounding scalp and the wound itself have been thoroughly disinfected. After these precautions have been taken the wound should always be carefully examined by inspection, the edges of it being retracted, if necessary, to get a clear view. The depth should be explored with a probe with such precautions of cleanliness and care as will ensure that no additional damage is inflicted. It frequently happens that in a wound of the scalp the aponeurosis, the pericranium, or both are divided in a small extent only of the wound. Similarly the skull itself may be implicated at one localized spot. For these reasons judicious examination with the probe should always be made.

Treatment.—An invariable rule should be made to shave the scalp for an inch or two round every wound. The more extensive the latter, the wider should be the margin of shaved scalp. In cases of extensive multiple or complicated wounds, especially with much contusion and grinding-in of dirt, an anæsthetic should be given and the whole head shaved. The patient will frequently think that such precautions are excessive, and the surgeon may sometimes be tempted not to insist upon them. Such relaxations will no doubt often be condoned by the sequel, but sooner or later the surgeon will meet with instances which will make him regret his complaisance.

After being shaved the skin should be washed with ether soap, cleaned with ether, and disinfected with a strong antiseptic. Tincture of iodine, while an excellent antiseptic for the skin, cannot be satisfactorily used if the surface has been wetted for the shaving; dry shaving of the scalp is usually too painful to be borne. The wound should now be thoroughly washed out with the antiseptic and carefully explored throughout. If there are much contusion and gross

contamination the surgeon should not hesitate to enlarge the wound if this is necessary to get at any part of it, or to excise begrimed and tattered fragments of the edges. No accidental *scalp wound should ever be stitched up tightly*. Superficial wounds and those not grossly befouled may be loosely brought together by a stitch or two Anything like close *approximation of the whole length of* a wound going through the aponeurosis should be carefully avoided, and in general it may be said that the deeper the wound the less *inclined should the surgeon be to stitch it up tightly*. Wet dressings should be used to encourage escape of blood and serum, and should be changed daily so that the wound may be inspected. If there is evidence that the surface of the skull is implicated, an anæsthetic should invariably be given. The best method of cleansing a grossly contaminated wound will then be the systematic excision of a layer from all its surfaces, including the chiselling off of a scale of bone, if this is exposed. The wound should then be sutured.

In all cases of wounds obviously contaminated with dirt a prophylactic injection of tetanus antitoxin should be given. Since we possess this easily-applied and harmless remedy, no case of a recent wound seen by a medical man should ever be allowed to develop the appalling complication of tetanus.

In cases of *detachment of the scalp* without complete separation, the flap should be cleansed, laid back in place, and fixed with a few stitches. It is well to cut the hair short and shave it in the neighbourhood of the tear. When there is complete separation of the scalp, grafting should be done soon, for otherwise the immense wound will never heal completely, and such attempts at healing as occur will cause deformity from traction on the surrounding tissues. Thiersch grafts usually take well when laid directly upon the skull. Covering the raw area wholly or in part with pedicled grafts should also be considered.

INFECTED SCALP WOUNDS

Suppuration is extremely common. When the wound is superficial to the aponeurosis the consequences are rarely more serious than the mere delay in healing Suppuration under the aponeurosis usually remains localized, and comes to the surface readily if the wound has not been closely sutured. Occasionally, however, streptococcal infections in this situation spread diffusely, giving rise to *cellulitis of the scalp*. This is accompanied by marked constitutional symptoms, a brawny œdematous swelling of the whole scalp, and œdema of the surrounding parts, shown, as usual, most strikingly in the eyelids. *Subpericranial suppuration*, which occurs, of course, *only* in wounds going down to the bone, is of great importance,

because it often takes place in cases in which the superficial part of the wound has healed rapidly. On this account the condition is apt to be overlooked in its earlier stages. In such a case the neighbourhood of the wound becomes œdematous, tender, and hot, and at the same time the patient shows the usual constitutional symptoms of an acute abscess, although the skin wound itself may be, and usually is, healing well. When the wound is opened up, pus is found under the periosteum, and the bone may already show evidence of impaired vitality; that is, over a part of the exposed area—not, however, usually extensive—it is white and avascular. Extensive necrosis of the skull is quite uncommon in these cases. Exfoliation of a small scale of the outer table is, as a rule, the most that follows from an uncomplicated subpericranial abscess. As has already been pointed out, but little in the way of necrosis of the skull can occur unless the diploë is involved.

Cellulitis of the scalp and subpericranial suppuration owe their importance to their tendency to cause cranial and intracranial complications—the former leading chiefly to sinus phlebitis and meningitis; the latter to osteo-myelitis, extradural abscess, and sinus phlebitis.

Treatment.—This does not differ from that of suppurating wounds in general, and need not be detailed. It is particularly important that there should be no delay. Cellulitis must be dealt with by free and early multiple incisions. These should follow the lines of the main vessels, but, however carefully planned, they are certain to bleed freely; they should therefore never be made without the use of a general anæsthetic.

In cases in which subpericranial suppuration has occurred it is well at once to have a culture of the organism made in order that a vaccine may be ready for use. Such cases, however, as a general rule do very well under prompt and free opening up and frequent dressing, and it is unusual for even superficial necrosis of the skull to occur.

DISEASES OF THE SCALP

These do not differ essentially from the diseases of the skin and subcutaneous tissues in general, and therefore need not be dealt with in detail Such aspects of them as are relatively special will alone be referred to here.

Tuberculosis and **syphilis** are scarcely ever met with apart from similar disease of the underlying skull, except in the frontal region. **Sebaceous cysts** are considered elsewhere (p. 669).

TUMOURS

Dermoids are described under Congenital Defects of the Skull (p. 509)

Angioma

Nævi of all forms are common. The larger cavernous nævi may show some respiratory pulsation, but nevertheless do not, as a rule, *penetrate the skull*. Sinus pericranii must not be confused with nævus.

All forms are usually to be treated by excision. But the large flat superficial forms are frequently better dealt with by radiotherapy or refrigeration with carbon-dioxide snow. Cauterization and electrolysis are to be avoided as tedious and uncertain.

Plexiform angioma (cirsoid aneurysm), *see* Vol. I., p. 442.

Lymphangioma (cystic hygroma) frequently encroaches on the scalp from the posterior triangle of the neck (*see ante*, p. 172).

Fibroma

Molluscum fibrosum, usually of the massive form, is not uncommon. On account of the ugly deformity it causes it should be excised. It is sometimes said that there is very free hæmorrhage during such operations. It is certainly never uncontrollable, and the supposed risk of it should not be regarded as a contra-indication to operation.

Fibroma of the epicranial aponeurosis is less common than in other aponeurotic structures, as also is "**fibro-sarcoma.**"

Neuro-fibroma of the sensory nerve trunks is common and often associated with diffuse fibroma molluscum. Such tumours, when the seat of pain, should be excised early; otherwise the removal of them is not so likely to relieve the symptoms.

Plexiform neuro-fibroma is not very uncommon on the scalp, *though not* usually confined to it. It begins early in life, and tends to spread progressively and fairly fast. It presents a characteristic diffuse soft solid swelling in which nodules and cords are readily made out. *Complete* excision is not likely to be possible, at any rate at one sitting, unless the swelling is unusually localized.

Sarcoma

Sarcoma primary in the scalp is a rare disease. It does not differ from sarcoma of the skin elsewhere.

Rodent Carcinoma

This form of carcinoma is quite common in the frontal region, quite rare elsewhere. It may take the early ulcerating or the tuberous form, in the latter case presenting a flat, very slightly pedunculated swelling with a scabbed surface and a substance much softer than might be *expected*. The disease when confined to the scalp is best dealt with, in whatever form it appears, by prompt and free excision the parts removed, if the skin alone be involved, including

the aponeurosis or frontalis. When the disease approaches the bone, the periosteum or even the outer table should be taken away. The wound left should be covered at the same sitting with Thiersch grafts. Such treatment in all fairly early cases affords a practical certainty of cure, and is over in a week or ten days. Treatment by radium may be regarded as a reasonable alternative to operation, though less certain in cases where a really radical excision is possible. Late cases in which extensive destruction of soft parts and bone has occurred are scarcely ever curable and should rarely be submitted to operation.

Epithelioma (Squamous Epithelioma)

This arises either primarily or as a development upon some other chronic lesion. When primary it usually begins in the warty form; when secondary it is more often ulcerative from the first.

The lesions in which the disease is apt to arise are sebaceous cysts (as described in a later article, p. 669), the chronic ulceration accompanying persistent gummatous disease of the skull, and scars, especially such as have originated from large granulating wounds and are liable to frequent injury. The point at which a chronic granulating surface develops into an epithelioma is usually difficult to determine. When starting in an unruptured sebaceous cyst the disease forms a tumour which for some considerable time is purely subcutaneous.

Apart from the points already mentioned and the difficulty of distinguishing it from the tuberous form of rodent carcinoma, the disease presents no diagnostic peculiarities in any way special to the scalp.

Treatment.—This should always consist in early and free *excision, with closure of the wound by some suitable plastic* procedure, followed by excision of the lymphatic glands to which the affected area is tributary. The determination of what glands are to be removed is sometimes difficult, and the ideal treatment will often have to be compromised, for example when it is a question of removing the parotid lymphatic glands. If these were not enlarged it would perhaps be *open to question whether the removal of them should* be insisted on, in view of the great risk of facial paralysis following an operation at all thorough.

PHYSIOLOGICAL PATHOLOGY OF THE SKULL AND BRAIN

Mechanisms by which cerebral symptoms are produced.—The symptoms of cerebral lesions in general are usually divided into irritative and paralytic. This clinical classification is based upon a real underlying pathological differentiation, and embodies a permanently valuable distinction.

Irritative symptoms are manifestations of activity in the absence of adequate normal causes. It is probable that, generally speaking, the irritative symptom is an exaggerated response rather than a true origination of activity in some part of the brain; that is to say, an evidence of increased excitability of the brain tissue rather than evidence of the presence of some intense local stimulation. Anything approaching in intensity the stimulation of the cerebral cortex by the faradic current probably never occurs in any circumstances of injury or disease. The conception that a piece of bone sticking into the cortex can produce fits, just as faradic stimulation will, receives no confirmation from the facts as studied experimentally or clinically. Anyone who has much experience of dealing with the brain at operations knows that mechanical stimulation of the cortex as by cutting, ligaturing, manipulation, and so forth produces no response. It is, however, not uncommon to find a contrary idea accepted, and this is probably due to the much greater attention attracted by and given to the experimental and clinical study of the *localization* of disturbances than to that of the nature and mode of production of disturbances. The use of the term irritative as applied to symptoms due to increased excitability is, strictly speaking, inexact, and no doubt somewhat misleading, since what it is desired to imply is abnormal irritability rather than actual excitation.

The brain being normally in constant receipt of and in constant response more or less obviously to stimuli, it is clear that an increase of excitability will satisfactorily account for the apparently spontaneous nature of many irritative phenomena. These, then, in all acute disturbances such as depressed fractures, hæmorrhages, and so forth, and in subacute disturbances such as meningitis, encephalitis, abscess, tumour, are evidences of increased excitability. Now, it is found experimentally that the excitability of the cortex cerebri bears a close relation to the condition of the circulation within it. Venous congestion of different grades up to complete stasis causes increase of *excitability*, while anæmia causes the opposite interference with function, namely *paralysis*. A portion of brain tissue totally deprived of blood is always totally paralysed, whereas a portion that is charged exclusively with venous blood shows heightened rritability.

Cushing found experimentally that if a glass window were fixed in a trephine opening in an animal's head the surface of the brain could be watched while fluid was injected into the cranial cavity so as to increase the intracranial tension and thus interfere with the circulation. During such an experiment a degree of increased pressure which produced congestion and cyanosis was accompanied by irritative phenomena. When the pressure was increased gradually, a point was reached at which the cortex suddenly became white and obviously anæmic. This was always marked by the onset of paralytic symptoms. Perhaps the most familiar instance of the effect of venous congestion of the brain is seen in the convulsions of asphyxia. It may, then, be laid down as a rule of general application that in the great majority of all cerebral cases, and in almost all acute cases, irritative symptoms mean venous congestion or stasis, and paralytic symptoms mean anæmia.

Physiology of the cerebral circulation.—From the foregoing considerations it is clear that, since practically all symptoms of intracranial lesions can be expressed in terms of circulatory disturbance, any peculiarities which the normal circulatory mechanism may there possess are of great practical importance.

The cardinal fact in the physiology of the cerebral circulation is that the brain and all its blood-vessels are contained within a rigid capsule of bone.

Blood enters the cerebral arteries at the pressure ruling in the carotids—say 150 mm. Hg. As it passes from arteries to arterioles and from arterioles to capillaries, the pressure rapidly falls until, by the time it gets into the veins and then the sinuses, it is but little above zero. The total sectional area of the venous outlets from the skull being considerably greater than that of the arterial inlets, the current of blood is much slower in the sinuses than in the arteries, though it is obvious that the amount of blood flowing through outlets and inlets must in a given time be equal. The veins and sinuses have together a much greater capacity than the arteries; hence there must be a large reservoir of blood on the venous side within the skull which might at any time undergo considerable diminution by an increase of pressure outside the veins, without the venous outlet being reduced below the capacity of the arterial inlet.

The blood-pressure in the veins and sinuses, being within the influence of the suction action of the respiratory movements, is variable within considerable limits. During inspiration the pressure in the torcular Herophili may fall to zero, while during expiratory efforts it may rise to 50 mm. Hg, or even more. The cerebro-spinal fluid is under pressure corresponding closely with the venous pressure, so that the general intracranial pressure is approximately the same as that in the veins. It is well known clinically that if for any reason the cerebro-spinal fluid is escaping through an opening in the skull, such as one in the cribriform plate, the rate of such escape has no relation to the arterial pressure, but follows the venous pressure very closely. The general intracranial pressure is the same in different parts of the skull under normal conditions. In abnormal conditions, as already mentioned in the section on Anatomy, the dural septa may, on account of dislocation of the brain, come to act as effectual partitions, and then widely different pressures may prevail in the various chambers. The brain tissue itself, being minutely permeated by capillary vessels, and being in itself semifluid and of slight rigidity in its substance, is at a pressure intermediate between the arterial and venous—the capillary pressure, which pressure, while considerably lower than the arterial, is less subject to fluctuation than the venous. Three grades of pressure can be distinguished as prevailing within the skull: (1) The general intracranial tension, which is that of the veins, sinuses, cerebro-spinal fluid of the ventricles and cisternæ. This is a low pressure, and is subject to respiratory fluctuations. It is that of the medium in which the brain is situated, and the fluids that stand at this pressure—venous blood, cerebro-spinal fluid—constitute a buffer which acts as a protection to the brain in a way presently to be noticed. (2) The capillary pressure, which is that of the brain substance itself—that is, represents most of the resistance which the brain offers when pressure is made on it. In compressing a part of the brain until it is rendered anæmic the capillary pressure has to be overcome in addition to the slight elasticity of the brain substance. (3) The arterial pressure. The arteries supplying the brain contain blood under a pressure the same as that in the carotids—very considerably higher, therefore, than that in the capillaries. This high pressure, being contained in strong-walled vessels, is, of course, shut off from being communicated to the brain substance or the cerebro-spinal fluid. The effect of a rise of the carotid pressure is to accelerate the rate of blood-flow through the brain. It can have no other effect as long as the arteries do not give way, and can therefore in itself produce no effect on function.

Irritative symptoms are manifestations of activity in the absence of adequate normal causes. It is probable that, generally speaking, the irritative symptom is an exaggerated response rather than a true origination of activity in some part of the brain; that is to say, an evidence of increased excitability of the brain tissue rather than evidence of the presence of some intense local stimulation. Anything approaching in intensity the stimulation of the cerebral cortex by the faradic current probably never occurs in any circumstances of injury or disease. The conception that a piece of bone sticking into the cortex can produce fits, just as faradic stimulation will, receives no confirmation from the facts as studied experimentally or clinically. Anyone who has much experience of dealing with the brain at operations knows that mechanical stimulation of the cortex as by cutting, ligaturing, manipulation, and so forth produces no response It is, however, not uncommon to find a contrary idea accepted, and this is probably due to the much greater attention attracted by and given to the experimental and clinical study of the localization of disturbances than to that of the nature and mode of production of disturbances. The use of the term irritative as applied to symptoms due to increased excitability is, strictly speaking, inexact, and no doubt somewhat misleading, since what it is desired to imply is abnormal irritability rather than actual excitation.

The brain being normally in constant receipt of and in constant response more or less obviously to stimuli, it is clear that an increase of excitability will satisfactorily account for the apparently spontaneous nature of many irritative phenomena. These, then, in all acute disturbances such as depressed fractures, hæmorrhages, and so forth, and in subacute disturbances such as meningitis, encephalitis, abscess, tumour, are evidences of increased excitability Now, it is found experimentally that the excitability of the cortex cerebri bears a close relation to the condition of the circulation within it. Venous congestion of different grades up to complete stasis causes increase of *excitability*, while anæmia causes the opposite interference with function, namely *paralysis*. A portion of brain tissue totally deprived of blood is always totally paralysed, whereas a portion that is charged exclusively with venous blood shows heightened irritability.

Cushing found experimentally that if a glass window were fixed in a trephine opening in an animal's head the surface of the brain could be watched while fluid was injected into the cranial cavity so as to increase the intracranial tension and thus interfere with the circulation. During such an experiment a degree of increased pressure which produced congestion and cyanosis was accompanied by irritative phenomena. When the pressure was increased gradually, a point was reached at which the cortex suddenly became white and obviously anæmic. This was always marked by the onset of paralytic symptoms. Perhaps the most familiar instance of the effect of venous congestion of the brain is seen in the convulsions of asphyxia. It may, then, be laid down as a rule of general application that in the great majority of all cerebral cases, and in almost all acute cases, irritative symptoms mean venous congestion or stasis, and paralytic symptoms mean anæmia.

Physiology of the cerebral circulation.—From the foregoing considerations it is clear that, since practically all symptoms of intracranial lesions can be expressed in terms of circulatory disturbance, any peculiarities which the normal circulatory mechanism may there possess are of great practical importance.

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Having defined the circulatory conditions normally existing within the skull, we must now consider the effects of disturbances of these conditions. The commonest and the most important case is the introduction *within the skull of a foreign body which limits the space normally filled by the brain and its accompanying fluids.* Of such intrusions a hæmorrhage of arterial origin and occurring outside the brain may be taken as a characteristic example. When an artery has been torn across there is nothing to check its bleeding—provided *the blood-pressure is fairly normal*—but the pressure existing within the skull. If the intracranial pressure, instead of being that of the veins, were equal to that in the artery, obviously no bleeding could occur. This is never the case with head injuries unless as the result of concussion the blood-pressure is very low. Suppose the carotid pressure, then, to be fairly normal, the wounded artery *will* bleed freely. Now, the skull being quite rigid to such pressures as we are concerned with here, and its contents as a whole being incompressible, this free bleeding can be accomplished only by the displacement of some of the cranial contents. Obviously the contents under lowest pressure would be the most easily expelled, and thus the bleeding from the artery will have the effect of causing, and will occur *pari passu* with, the expulsion from the skull of some of the blood from the sinuses and veins and of some of the cerebrospinal fluid. The latter will be displaced downwards through the foramen magnum, and will also escape into the sinuses. Seeing that the total capacity of the veins and sinuses is considerably greater than that of the arteries, it is clear that the expulsion of cerebrospinal fluid and of venous blood can go on until the veins and sinuses have been compressed up to a certain point, without the circulation being in any way embarrassed. *This point is reached when the total venous outlet is reduced to the size of the total arterial inlet*; up till then the escape of blood from the brain will be unimpeded and will be equal to the intake. Therefore there is no venous congestion, and consequently no symptoms arise and the hæmorrhage is so far *clinically latent.*

Supposing the hæmorrhage to continue, it will go on obtaining space for itself by causing further compression of the veins, and will now actually diminish the accommodation for venous blood and the escape of it from the skull below the needs of the supply which is still coming in from the arteries. Consequently a condition of venous congestion is established. The compression of the venous channels may go on until the sinuses of the dura actually collapse. During this stage the cortex cerebri becomes visibly cyanotic. These are the physical processes which result in the pathological condition of *increased* excitability and the clinical condition of irritative symptoms.

If the hæmorrhage continues it must gain room by displacing fluid which is at a higher pressure than that which has already been displaced, namely, that in the capillaries of the brain. This involves an actual compression of the brain substance itself, which diminishes in bulk and becomes obviously white in colour as the blood is squeezed out of its capillaries. In his experiments Cushing was able to watch the colour change from the blue tinge of cyanosis to the dead white of anæmia. This physical condition of anæmia is, of course, accompanied by the pathological state of inexcitability of the cortex and the clinical manifestations of paralysis.

So far we have, for the sake of clearness, dealt with the circulatory effects of an intracranial compressing agent as if the latter were diffused over the entire surface of the brain and produced disturbances which were equally distributed throughout the whole cranial cavity. Such, however, is never the case in practice, and conditions of this kind can be met with only experimentally when a hæmorrhage is simulated by injecting fluid into the subdural space. In actual practice, when the cause is, for example, a hæmorrhage, this is essentially local, and exercises its effect primarily upon the brain in its vicinity only. The disturbances produced locally are, however, precisely as described, and the same stages are gone through, namely, compression of veins without obstruction, compression of veins with obstruction and venous congestion, and finally anæmia. The symptoms will be first irritative and then paralytic, though they will point to the implication of a part rather than of the whole brain. Again, it is obvious that the part nearest to the hæmorrhage will be more affected than parts distant from it. Thus at one and the same time the brain in immediate contact with the hæmorrhage may be in the stage of anæmia and paralysis, while farther away there will be a zone of brain tissue in a condition of venous congestion and increased excitability, and beyond this again the brain will be normal. It is a simple corollary from this arrangement of the disturbance that the congested region will be, as a rule, more extensive than the anæmic region, and consequently it will be a clinical fact that symptoms of increased excitability are more widespread than symptoms of paralysis.

As the hæmorrhage (or other cause of compression) increases in size its sphere of influence on the adjacent brain will expand until possibly symptoms are present showing that the whole of the brain is to some extent disturbed. This implication of the whole brain will not, however, until the patient is actually moribund, be of equal intensity everywhere, but will always show a gradation of diminishing disturbance from the region of the hæmorrhage towards the more distant parts. In a very broad way it may be laid down

that the extent of implication of any given part of the brain will be in inverse relation to its distance from the lesion. If the cranial cavity were of simple form, its interior unbroken by septa, and the sensitiveness of the brain to disturbance equal throughout, the rule would be absolute. Since, however, this is very far from being the case, there are many complications to be allowed for and many corrections to be applied in actual practice. (Fig. 734.)

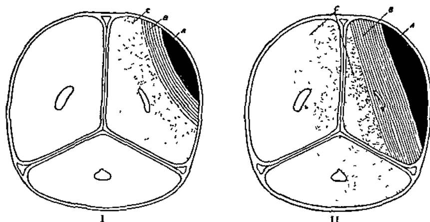


Fig. 734.—Schematic section of skull to show distribution of circulatory changes in the neighbourhood of a hæmorrhage.

A, Blood-clot; B, anæmic zone; C, congested zone. I, Early stage. II., late stage. In the former the symptoms would be chiefly hemispheral; in the latter, irritative bulbar symptoms would be present.

INJURIES OF THE SKULL AND BRAIN

Head injuries owe their importance almost solely to the effects they have upon the functions of the brain, and it is therefore desirable that they should be classified according to the way in which the various cerebral disturbances due to them are produced. Of such disturbances three fundamental classes can be distinguished:

1. *Conditions due directly to the energy of the external force.*—The force of the blow on the skull is conveyed to the intracranial contents and causes disturbances of circulation or structure therein. These effects are produced in the very moment of the accident.
2. *Conditions set going by the external force but owing their development directly to the circulatory activities of the patient.*—Hæmorrhage and œdema are the typical effects belonging to this class. It is an essential characteristic of them that their clinical manifestations are never of instantaneous onset, but are separated from the time of the accident by an interval of greater or less duration.

3. *Conditions due to the introduction of micro-organisms.*—Here the relation between the morbid condition and the injury is merely that the latter provides a portal of entry for the organism and possibly an abnormally favourable soil for its growth. The clinical manifestations of such conditions are always separated from the time of the accident by a distinct interval. These infective complications of head injury do not differ essentially from non-traumatic infections, and will therefore be described with them.

The first two groups of this classification will be treated in the present section. A tendency is sometimes seen to deal with the conditions referred to as complications of fracture of the skull. This method of approach is an unsatisfactory one, and is likely to lead to excessive importance being ascribed to fracture, and to attention being distracted from the cerebral conditions, which are much more serious, and which may occur without the coexistence of fracture at all. It is of much greater practical value to concentrate attention upon essential cerebral disturbances present, and to deal with fracture as an incidental circumstance which, though important, is not of primary significance as regards the survival and cure of the patient.

IMMEDIATE CONSEQUENCES OF HEAD INJURY, INCLUDING CONCUSSION, CONTUSION, AND LACERATION OF THE BRAIN

I. Physical Considerations

Physically considered, the skull is by no means the rigid structure it appears to ordinary observation to be. When external force is applied to it, it is capable of yielding to a remarkable degree without breaking, and of recovering its normal form with great elasticity. This capacity for undergoing temporary deformation is well established experimentally. It is the most elementary mechanism by which cerebral symptoms are produced.

The degree and form in which deformation occurs must obviously depend on the nature of the external violence by which it is caused. When a man falls on his head on to a flat surface the skull is compressed between the ground and the weight of the body applied through the spine to the occipital condyles. In these circumstances the skull bends as a whole and undergoes what may be called " general deformation " ; it is flattened at the poles to which the violence is applied, and though it bulges at the corresponding equator, the total effect is a sudden irresistible diminution of the cranial capacity. If the force applied is such as to deform the skull beyond the limits of its ability

to yield continuously, a fracture results. On the other hand, when the skull is struck by a small or pointed object possessing the necessary momentum the inbending of the bone is limited in area and local deformation only occurs, with or without fracture. In this case there is no general diminution of the cranial capacity, and therefore none of the clinical consequences of such a condition.

It is important that the essential physical differences between typical cases of general and of local deformation should be kept in mind, for though the distinction is not always in practice absolutely sharp, the extent and severity of the immediate cerebral symptoms of a head injury are always strictly proportionate to the amount of general deformation.

The inbending of the bone which occurs when the skull is violently struck produces effects upon the intracranial contents by two modes of action: one the sudden momentary diminution of the cranial capacity, and the other the infliction of a blow upon the immediately underlying brain. These will be considered separately.

Diminution of the cranial capacity.—The physical conditions normally obtaining may be represented schematically with sufficient accuracy if the skull be regarded as an elastic sphere containing a soft, sponge-like solid. The meshes of the sponge are filled with fluid which also occupies such spaces as are left between the outer surface of the sponge and the sphere which encloses it. The intracranial space is thus completely occupied by its contents, and any diminution of it must be accompanied by a corresponding diminution of its contents—that is to say, by some of the latter being *displaced out of the cranial cavity.*

The *amount* of the contents displaced will always exactly correspond with the amount of encroachment on the cavity; the actual material displaced and the distribution of the accompanying disturbance will depend entirely on the *force* and *rapidity* of the encroachment. When the encroaching force is applied slowly—as, for example, in the case of a hæmorrhage—the blood-vessels in its *immediate neighbourhood* are pressed upon, and their contents are squeezed out always in exact proportion to the size of the encroachment on the cranial cavity. The effect is thus a local one, and remains so, though with the increase of the hæmato[illegible] r and larger part of the brain is aff[illegible] ed. When the e[illegible] *force* acts very rapidly, as when[illegible] bends in under [illegible] low, the effect is no longer lo[illegible] e is no time [illegible] ual expression of the contents [illegible] in the neigh [illegible] the part struck, but the force [illegible] hroughout t[illegible] cavity and is applied to all [illegible] ike instant widespread conduction of t[illegible] cted thro

which surround and interpenetrate the brain so as to constitute a very large proportion of the cranial contents and to act in the conduction of rapidly acting forces like a continuous fluid mass. The encroachment on the intracranial space in this case, then, is met not by a local but by a general expression of the intracranial contents to a corresponding amount. Of the contents the fluids, being the more mobile, are those which in an ordinary case provide the material that is displaced out of the skull. When the violence of the injury is very great the relatively greater consistence of the brain is no longer a determining factor, and the brain substance behaves as if of equal mobility with the fluids, and is expressed with them. In an ordinary case, however, the brain is squeezed like a sponge. The difference between the resistance of the veins to compression and that of the arteries is, of course, so inconsiderable in comparison with the force acting upon them that all vessels yield alike, arteries no less than veins. It may be supposed, therefore, that as the compression is quite general, the extent to which any given portion of the intracranial contents yields is practically the same as that of any other, whether the resistance it offers is chiefly that of the capillary, the venous, or the arterial pressure. A very small amount of compression will serve to cause obliteration of the capillaries and anæmia of the brain substance, so that as, in the case we are considering, the compressing force is applied to the capillaries from the first and equally with the other vessels, it follows that widespread capillary anæmia of a more or less severe grade is instantaneously produced, and leads to corresponding paralytic symptoms The duration of this compression is, of course, but momentary. Immediately after the blow the skull regains its form and the emptied capillaries mechanically refill.

We reach the conclusion, therefore, that when the skull undergoes rapid and energetic deformation a considerable part of the acting force is distributed throughout the cranial cavity as a sudden increase of tension which expels from the skull an amount of fluid corresponding with the inbending of the skull, that this expulsion of fluid is accompanied by more or less anæmia of the brain, with a consequent condition of paralysis, and that the characteristics of this paralysis will be its instantaneous onset, its wide distribution, and its tendency to pass off spontaneously. This is the clinical condition known as *concussion* in the strict sense of the term. (Fig. 735.) The foregoing considerations will have shown that on its pathological side concussion may be described as a hyperacute general compression of the brain.

We have seen that under different conditions of rapidity in the application of a compressing force the intracranial contents show

striking and very important differences of behaviour. It will be convenient to mention here a remarkable phenomenon which may appear when the velocity of the blow is very much greater than any we have considered. If a high-velocity rifle bullet passes at short range (within about 50 yards) through the cranium longitudinally close to and parallel with the base, the whole vault of the skull, as is well known, is apt to be blown off; but at the same time it sometimes happens that the *brain itself*, practically without laceration, is thrown out of the skull, the two hemispheres, though separated from one another, remaining otherwise intact and being found lying near the body of the victim. The amount of disintegration of the hemispheres may be so slight as to make it seem certain that they have been removed post mortem. The condition has, however, been produced experimentally. It shows that in presence of the almost inconceivably great rapidity and force of what amounts to an explosion under it, the semi-solid brain behaves as if it possessed a high degree of consistence. The injury was first described by Kronlein, and is usually associated with his name (Krönlein's *Schadelschuss*). Apart from its theoretic interest, it might possibly be of medico-legal importance.

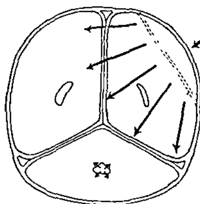


Fig. 735. — *Scheme of the* mechanical effect of a blow on the skull. Mechanism of the *concussion* factor.

The dotted line represents the position to which the skull is momentarily inbent The arrows show the direction of the blow and the distribution of its effects within the skull The small arrows within the 4th ventricle indicate the displacement of cerebro-spinal fluid along the central canal (according to Duret's hypothesis) and the consequent pressure on the medulla.

Impact of the inbending skull on the underlying brain. —*In spite of its soft consistence*, the brain itself, when struck, behaves like a solid body, and transmits directly a considerable part of the force with which the skull *is driven in* upon it. The effects of this direct component are found chiefly in the path through which it is transmitted, and that is in the direction in which the skull strikes the brain, and a straight line prolonging this direction. The effects are as follows :—

(*a*) *Local effects at the site of the blow. Local contusion or laceration.* —At the point struck the brain is discoloured with extravasated blood and its normal contours are more or less obscured. In a moderately severe case an area 2 or 3 in. in diameter is thus contused, and the change is superficial, not commonly extending in depth recognizably to the naked eye more than about ¼ in. There may be visible

laceration of the contused area, but not usually unless a local fracture of the bone has occurred.

(b) *Polar contusion or laceration. Contusion or laceration by contre-coup.*—The force of the blow is not usually exhausted in causing local contusion. The brain is driven in the direction of the blow and into violent contact with the opposite side of the skull. It may and usually does suffer contusion or even laceration from the contact, and such a lesion will occur on the surface of the brain diametrically opposite to the point of primary impact. The force with which the brain is thus driven against the skull is well shown by the cases in which fracture of the roof of the orbit has been caused by this mechanism. Polar contusion may be brought about by impact of the displaced brain against the dural septa as well as against the skull. The falx cerebri, the tentorium, and the falx cerebelli are very often the cause of polar contusions. Of such, those which are produced by the tentorium are the most important, as they lead to contusion of the cerebellum, and tend to cause the very serious complication of increased tension in the posterior chamber of the skull. Blows on the front or back of the head are especially likely to cause this complication, which accounts for the fatal termination of many cases of apparently slight injury.

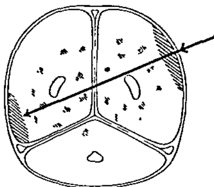


Fig. 736.—Scheme of the mechanical effect of a blow on the skull. Mechanism of the *contusion* factor.

The arrow indicates the direction of the blow and the transmission of force by the brain. The shaded areas show the direct and polar contusions and the contusions within the brain substance.

(c) *Contusion of the brain substance.*—The transmission of such a powerful force as that which leads to contusion by contrecoup exposes the brain substance to stresses and distortions which tend to cause various lesions in it. These take the form of small hæmorrhagic and contused areas found chiefly along the line of greatest disturbance—that is, the tract lying between the direct and the polar contusions. (Fig. 736.)

(d) *Contusion of the ventricular walls.*—It is supposed with some probability that when great force is suddenly applied to the hemispheres some of it may be transmitted to the fluid in the ventricles, forcing this along the central canal under a pressure abrupt enough to cause contusion of the walls of the aqueduct and the fourth ventricle. Such an impulse to the ventricular fluid would owe its force not merely to the direct blow on the brain, but also to the sudden

general increase of intracranial tension which has been already described. This mechanism is very far from being as well established as the three just described. It is a fact of observation, however that areas of contusion are somewhat specially liable to appear in and about the ventricular walls, and the hypothesis serves at least to call attention to this not unimportant fact.

II. Clinical Features, Pathology, and Treatment of Concussion

Concussion is to be defined as a condition of widespread paralysis of the functions of the brain which comes on as the immediate consequence of a blow on the head, has a strong tendency to spontaneous recovery, and is not necessarily associated with any gross organic change in the brain substance.

Symptoms.—Since the onset of the condition follows immediately upon the receipt of the injury, and the symptoms soon begin to clear up spontaneously, it is comparatively rare for the surgeon to have an opportunity of examining a patient while the condition is at its maximum. Such opportunities, however, occasionally occur, and perhaps one of the best known is Gussenbauer's classical case.

In a well-marked case the patient instantaneously loses consciousness. If he is standing at the time of the receipt of the blow he falls and lies like a log; if the violence is the result of a fall the patient lies where he has fallen, motionless in the posture in which he struck the ground

The loss of consciousness at this moment is absolute; no stimulus meets with the slightest response The limbs are flaccid and all the muscles relaxed. This relaxation in such severe cases involves the sphincters, and may lead to the escape of urine or even fæces. The face is pale, the skin moist and cooling rapidly. The pupils are dilated and at the moment of the onset may not react. The respiration is shallow sometimes scarcely perceptible, though now and then marked by a deeper sighing breath. For a short period there may be total cessation of the breathing. If a wound has been received at the time of the accident it does not bleed, and its surfaces are pale. The pulse may be imperceptible, and the action of the heart weak and fluttering. Different cases show differences in the pulse-rate, which is, however, never normal. *Quickening is* perhaps the common change, and may be accompanied by irregularity. Slowing is less common, and probably, it may be added, less serious than marked quickening. In some cases actual cessation of respiration and of the heart-beat have been described, and, as we shall see later, may very likely occur not infrequently. This sudden great diminution or actual arrest of all the grosser vital

processes bears a very close resemblance to death itself, and may pass into it. That it does not do so more often is no doubt due to the circulatory system being, apart from the effects of the accident, in a healthy condition, for there can be no doubt that a patient brought to an equal degree of circulatory failure by disease, by hæmorrhage, or by shock could not recover.

After a few minutes of this uttermost state of collapse, if the patient does not actually die, slight signs of recovery begin to appear, and he passes into the state usually observed by the surgeon. The pulse can be felt at the wrist; the respiration, though faint and sighing, is once more perceptible; and the patient may make some response to stimulation, and even stir or attempt to answer when spoken to loudly. The pupils, though dilated, contract sluggishly when illuminated.

The other reflexes, all of which have been absent in the stage of profoundest collapse, may begin to return, but, as a rule, they lag far behind the pupillary reflex. As is well known, the last-named is of all the reflexes that which is most resistant to circulatory failure, and is correspondingly early in returning during recovery. This condition may last some little time—half an hour to several hours, but not usually beyond an hour, while frequently the duration is less than half an hour. Recovery from it is usually rather sudden.

The visceral reflexes return, with the result that the first sign of recovery frequently is that the patient vomits The raising of the blood-pressure accompanying this brings about a speedy return of consciousness, the pulse and colour improve, the respiration becomes normal This stage of reaction, as it was well named by the older clinicians, is almost constantly accompanied by certain symptoms, of which the most constant are headache, giddiness, nausea, tremulousness, and general weakness. These usually persist for some hours, but generally pass off within a day Before doing so they may show some intensification, and to them may be added slight elevation of temperature, full bounding pulse, sleeplessness, irritability, general discomfort, restlessness, and even delirium.

Such may be taken as a representative picture of a severe uncomplicated concussion of the brain. Variations in the symptoms are very common. Frequently the condition is much less severe. A blow on the head may give rise merely to a transitory dizziness followed by some headache, or it may cause a transient loss of consciousness without any serious circulatory symptoms. This is a very common clinical type. Very abruptly acting injuries, such as high-velocity bullet wounds, may cause evidences of extensive excitation of the brain, such as arrest of respiration with inspiratory spasm, and slow (vagus) pulse or complete cardiac inhibition. Such a symptom-

group has been frequently obtained experimentally (Horsley and Kramer, Maasland and Saltikoff), and probably also occurs under similar circumstances in the human subject. It is evident that it is unlikely to be met with clinically, especially in civil practice, for even if it were commonly produced by head injuries either it would have passed off or the patient would have died by the time the surgeon had an opportunity of making an examination.

Pathology.—The three words concussion, commotion, and contusion are often used in connexion with the condition we are discussing. The meanings attached to them are not always very clearly defined. In this article no technical meaning will be ascribed to the word "commotion," and it will not be used to describe any result of injury; "contusion" will be used in the ordinary sense of "bruise"; while "concussion" will indicate the condition already defined clinically and characterized pathologically by the absence in uncomplicated fatal cases of any gross organic lesion such as could have caused the symptoms. This, of course, is not to say that in patients who suffer from concussion and die soon afterwards no gross lesion of the brain will be found. As a matter of fact, uncomplicated concussion rarely causes death, so that the mere fact of death occurring is strong presumptive evidence that some gross lesion such as contusion, laceration, or hæmorrhage is present.

The sudden loss of consciousness and the generalized muscular collapse are clearly paralytic signs, and suggest that the seat of the paralysis is the cerebrum. The respiratory and circulatory signs point to a disturbance of the bulb; cessation of respiration and rapid small pulse are apparently paralytic effects, while the shallow sighing breathing so often seen is a minor grade of a similar disturbance. The proximate physical cause of paralytic lesions of the brain is well known to be anæmia of the cerebral tissue. In discussing the physical effects of a severe blow on the skull we have shown that there is produced a momentary hyperacute compression of the brain which tends to cause a capillary anæmia varying in severity with the amount of encroachment on the intracranial space by the inbending skull. This mechanism furnishes a logical and consistent explanation of the manner in which concussion arises. It is, with some modifications, the hypothesis originally advanced by Strohmeyer many years ago. The principal evidences tending to confirm it clinically are, first, the obviously paralytic nature of the symptoms; secondly, the fact that these tend to disappear spontaneously; thirdly, the fact that in certain cases in which death occurs no change in the brain capable of accounting for the symptoms is found; and fourthly, and perhaps most important of all, the *absolutely instantaneous* onset of the condition upon the receipt of the blow.

Moreover, concussion is most characteristically produced by accidents which cause general deformation of the skull, and is usually altogether absent from cases, even with severe cerebral injury, in which the deformation has been strictly local.

Many hypotheses have been enunciated in explanation of the pathology of concussion. Some of the more notable ones must be referred to in a summary way.

"Molecular disintegration of the brain tissue" has been credited with being the underlying condition in concussion. In support of this view are quoted the experiments of Koch and Filehne, in which conditions resembling concussion were produced by repeated percussion of the skull. Such symptoms, as pointed out by Kocher, are probably due to ordinary surgical shock, and, moreover, provide no explanation of the abrupt onset of the concussion. In addition, the phrase "molecular disturbance or disintegration" cannot, when critically examined, be regarded as having any meaning capable of expression in pathological terms.

Multiple microscopic lesions, destructive or degenerative, are regarded by some as being of great importance in the production of concussion, and are held to account for some of those cases in which macroscopically no lesion is discoverable post mortem. That such lesions, which are described by observers of undoubted repute, have, in fact, much to do with the production of concussion symptoms seems improbable. It is difficult to see how they could be so numerous and so widespread as to cause instantaneous loss of consciousness, and still more difficult to see how, if they produce the symptoms by destruction, the tendency to a complete recovery is so strong. To attribute to them, as was done by Gussenbauer, the losses of memory which are so common is to make an assumption which goes far beyond the evidence. We know nothing of the relation of organic lesions to absolute as distinguished from specific amnesias.

Duret's hypothesis of "cerebro-spinal shock," due to the forcing of cerebro-spinal fluid from the lateral ventricles and its impact under great pressure against the walls of the aqueduct and the floor of the 4th ventricle so as to cause organic damage there, is also inconsistent with the fact of complete recovery being so common. That contusion of the brain may sometimes be produced in this way is possible enough, but that would have little relevance to concussion in the ordinary sense. Possibly this mechanism may assist in producing the momentary anæmia of the bulb which is the cause of the circulatory and respiratory symptoms of concussion.

Tillmann's hypothesis, based on the differing specific gravity and inertia of the various intracranial fluids and tissues such as blood, cerebro-spinal fluid, grey matter, white matter, is to the effect that

in consequence of a blow on the skull the inter-relation of the cortex and white substance is disturbed, presumably by organic interruption. The argument from recovery is equally applicable here, as is also the fact that, though microscopic lesions are sometimes found when no macroscopic ones are present, there are undoubted cases in which microscopically the brain is normal.

Although we can accept none of these hypotheses as a substitute for that which regards cerebral anæmia due *to hyperacute compression* of the brain as the cause of the symptoms of concussion, yet the work which has been done in support of them has been of great value in enlarging our conception of the injuries to which the brain is liable. The numerous small injuries which we now know frequently to occur in these cases help to explain the many variations in the recovery from concussion. Thus, while we may lay it down definitely that the onset and collapse stages of concussion are invariably of circulatory origin, *and not influenced by the accompanying* minor injuries of the brain which are shown to be common, we may acknowledge that these latter may be of sufficient importance later to modify the course of the stage of reaction.

In dealing with the pathology of the period of reaction it is obvious that there are three factors which must be taken into account as sources of the symptoms first, delayed and imperfect recovery of the circulation in the brain; secondly, the effects of the more or less prolonged cerebral anæmia; and thirdly, the effects of injury to the brain tissue actually inflicted at the time of the accident. The primary profound anæmia due to expression of blood from the brain does not, of course, last for more than a very short time, otherwise the injury would necessarily be fatal. We may suppose that the rebound of the skull to its normal shape necessarily aspirates blood into the vessels which have been partially or completely emptied. This reflux will probably be more complete and rapid in the veins than in the capillaries, so that some, at any rate, relative anæmia of the brain substance will persist after the cause of it has ceased to act, and be prolonged by the feebleness of the general circulation. It is still longer before the circulation has finally steadied to the normal, and the secondary disturbance of the cerebral circulation during this period is probably the cause of the faintness, giddiness, and nausea which often persist well into the period of reaction.

Small or even microscopic foci of contusion scattered throughout the brain substance, and in the parts immediately surrounding *the* ventricles, could not in themselves produce immediate symptoms of a general involvement of the brain, and could not cause the onset of symptoms of concussion unless they were concentrated with

remarkable precision in certain regions. If they were important factors in the causation of the immediate symptoms, the clinical picture produced would be made up of congeries of focal symptoms variable among themselves instead of the relatively stable clinical picture of a generalized involvement of the brain which is characteristic.

How, then, it may be asked, can such lesions be regarded as producing the symptoms of the later stages of concussion, which are also those of a generalized cerebral disturbance? As we have said, in this stage evidence of a variable amount of increased excitability of the brain is apt to appear, as is shown by headache, full bounding pulse, raised temperature, restlessness, more or less mental clouding, and even delirium. Such general irritative symptoms can be due only to a slight degree of increased intracranial tension. This general increase of intracranial tension can be correlated with the scattered lesions of the brain substance when it is remembered that these latter tend to cause œdema in the parts surrounding them. A slight general œdema of the brain is therefore probably a constant sequel within some hours of the production of these minute lesions, and may well be the cause of the common irritative symptoms.

These considerations relative to the pathology of the reaction period of concussion, while embodying a considerable element of hypothesis, are consistent with the well-established facts of cerebral pathology, and are supported by the collateral evidence that they make a satisfactory basis for treatment. Such considerations have the practical value of indicating how it is that the reaction stage of concussion provides an intermediate series of conditions passing into those states of persistent compression of early onset to which the terms commotion and contusion have been somewhat confusingly applied.

Diagnosis.—The diagnosis of concussion is always easy. In a well-marked case the three elements of instantaneous onset, loss of consciousness, and circulatory failure are characteristic. To determine whether there is accompanying destructive injury of the brain is altogether more difficult, and in the majority of cases quite impossible until some time has elapsed since the injury was received. It is of the first importance, therefore, for the surgeon to recognize that no amount of skill and no length of experience can justify him in pronouncing during the collapse stage of concussion upon the presence or absence of intracranial lesions.

Prognosis.—A very small number of patients die during the collapse stage from circulatory failure. But few of these cases are uncomplicated by grave destructive injuries. A very large proportion of patients recover completely, but many of them develop

persistent minor symptoms of a more or less disabling kind. In a considerable number of cases gross organic damage will have been done to the brain, and will manifest itself usually within a few hours of the accident, sometimes not for several days, and rarely not for several weeks. A patient who has received a severe blow on the head cannot be regarded as free from liability to these extremely serious complications until three weeks or a month after the accident. These long-delayed hæmorrhages, though decidedly rare, are quite well known. They seem in some cases to originate from areas of softening in the substance of the brain or on its surface which are due to contusions received at the time of the accident. Contusions of this kind may as such produce no symptoms whatever, so that the hæmorrhage may occur abruptly in a patient who is supposed completely to have recovered from his accident A certain reserve, therefore, should be exercised in giving a definite prognosis in any case of head injury.

Sequelæ.—Recovery from concussion is apt to be delayed or interrupted by the occurrence of various residuary symptoms Of these, *headache* is the most important and characteristic, but with it may occur *giddiness, tinnitus, impairment of memory and attention,* and *slight changes of disposition.* It has been common to regard such symptoms as in the nature of neuroses due to the accident, but the growth of experience has rendered a different interpretation necessary. As has already been shown, the deformation of the skull which causes concussion very commonly also produces some degree of contusion of the brain substance Indeed, when the phenomena of the so-called stage of reaction are at all well marked, the existence of a considerable amount of such contusion may confidently be inferred. Now the brain, enclosed as it is by a capsule—the cranium—which is altogether inextensible by physiological forces, is placed in a uniquely unfavourable position for recovery from a bruise. For any other organ free swelling is the normal response and method of recovery in such circumstances; thus the circulation is maintained unimpeded and absorption of extravasated material is prompt and complete. In the brain, however, the simplest contusion is apt to be a very persistent lesion. Swelling being restricted by the skull, the circulation through the bruised region is embarrassed and absorption extremely slow. Such an *unresolved contusion* manifests itself not usually in the form of local symptoms but as a chronic or recurrent elevation of intracranial tension. When the condition is severe there is evidence of continuously raised pressure, while in moderate and mild cases there is evidence that the intracranial space is encroached upon no more than enough to cause undue pressure in special circumstances.

The headache that is so common as a sequel of concussion shows evidence in its clinical characters that it is of organic cerebral origin

and that it is due to an interference with the mechanisms by which the intracranial pressure is normally regulated. There can be little doubt that this interference is brought about by the persistence of unresolved contusions set up by the violence which also caused the concussion.

This headache has characteristic modes of onset: it may persist uninterruptedly from the period of reaction, it may come on when the patient first gets out of bed during convalescence, or it may attend his resumption of active life.

It is of severe and sometimes agonizing intensity and of a bursting, throbbing character. It is rarely continuous, but usually occurs, in attacks between which the patient feels quite well. The attacks may last for a few hours or two or three days; they are apt to be brought on by exertion, excitement or fatigue. During the attacks the patient is intolerant of light, of noise, and of mental and physical effort; he is apt to become irritable, to resent interference, and to insist on being alone and undisturbed; in severe attacks he may become maniacally excited. In the milder cases all the manifestations are less severe and the attacks infrequent and not readily brought on Even in these cases, however, the amount of disablement for an active life may be serious.

The other residuary symptoms we have enumerated are usually associated with headache and do not need separate consideration. Of other sequels, little more than a bare mention of *epilepsy*, *insanity*, and *traumatic neuroses* is necessary These may all be regarded as likely to occur only in patients already strongly predisposed to them. There is no special liability for traumatic neuroses to be precipitated by accidents which have caused well-marked concussion. Indeed it is probable that the absolute amnesia for the period of the accident that is characteristic of concussion is in some degree a safeguard against such complications

Loss of memory.—When a patient who has had well-marked concussion tries to recall events preceding the accident he finds that his memory is quite good for such of them as happened up to a certain point of time before the accident—usually half an hour or an hour—and then abruptly ceases, there being a complete gap until the point when consciousness was recovered. This amnesia is absolute and unbroken by the faintest trace of any recollection whatever, and is generally permanent. So frequent is it that it is of some medico-legal importance, for when it occurs it renders the patient quite unable to give any account whatever of the accident, or even sometimes of the events which led up to it. The interpretation of such losses of memory is extremely imperfect. They have been regarded as due to organic brain lesions, possibly of a very fine quality, and quoted as

evidence that permanent organic damage is inflicted in cases of even moderate concussion. The evidence for this conclusion is quite inadequate.

In connexion with the subject of post-traumatic amnesias it is necessary to refer shortly to the *automatic states* which sometimes follow immediately upon a head injury. When concussion has been slight it sometimes happens that, though consciousness is recovered rapidly, the mental state does not return at once to the normal. In this condition the patient is liable to perform various complicated acts which are in the circumstances irrelevant, absurd, or even dangerous. This "automatism" is of considerable medico-legal importance, for the subject of it, though possibly to all appearance natural enough, cannot be regarded as responsible for his acts. Such conditions vary greatly in their fullness of development and their duration. In the simplest case the patient is dazed, does not realize where he is, and talks confusedly for a few minutes before coming to himself, as a rule rather suddenly. In the more fully developed cases the patient may carry out complex and apparently voluntary acts for some hours, and be totally unaware afterwards of what he has done.

Treatment.—During the collapse stage of concussion the treatment should be governed by two considerations (1) that the actual danger of fatal collapse is small; and (2) that since the surgeon cannot know what intracranial injuries may have been sustained he should abstain as long as he can from doing anything to raise the blood-pressure and so increase the danger of hæmorrhage.

The patient should be kept in the horizontal position and well wrapped up. A summary examination of the nervous system should be made, the condition of the scalp and skull ascertained, and the possibility of any injury of the limbs and trunk excluded as far as may be with a minimum of disturbance. The pulse should be kept under observation, and if it seems to be flagging dangerously the lower limbs may be raised and bandaged and a hypodermic injection of strychnine given. In the ordinary cases stimulation can, however, be altogether avoided.

In some cases, in the rare possibility of the surgeon being present at the time of the accident, he may find that there is a complete arrest of respiration. In such circumstances artificial respiration should be used, but with a minimum of disturbance of the patient.

In the period of reaction the patient should be kept in bed in a darkened room, in charge of a competent nurse, and should not be disturbed by relatives or visitors. A purge should be given, and the diet restricted to fluids. If headache is severe an ice-bag should be applied to the head. Restlessness should be met by warm sponging

and by large doses of bromide per rectum. Morphia is to be avoided, first because it may prove to be an excitant, and secondly because of its paralysing effect on the respiratory centre—a centre which has but just recovered from a severe disturbance and may in the near future be exposed to still further danger should an intracranial hæmorrhage occur. Within forty-eight hours all irritative symptoms will have disappeared in a case of normal course. The patient should, however, be kept in bed for a week or ten days, according to the severity of the reaction symptoms, and should not be allowed to get about at all freely for three weeks after the accident. All kinds of exertion should be forbidden during this period, and that most dangerous exercise, straining at stool, should be rendered impossible by attention to the bowels. These precepts represent the treatment which is demanded by what we know of the pathology of cerebral injuries, and especially the liability to delayed hæmorrhage. It is, however, to be feared that the surgeon will often find them regarded by his patient as impossible counsels of perfection. It should be explained to the patient that less cautious treatment carries with it a certain, though of course not very great, risk.

The return of the patient to active life after an accident causing well-marked concussion is always to be regarded with some anxiety. If it is at all possible, a full month must be allowed beyond the three weeks already mentioned before the patient is allowed to take up ordinary activities. During this time he should lead an easy, protected life, in which he is allowed to undertake only those activities to which he is perfectly adequate.

The occurrence of the characteristic headache or of other manifestations suggestive of unresolved contusion must be dealt with seriously. Rest in bed is the essential measure. If headache persists from the period of reaction the patient should be kept in bed. If it comes on later he should be sent back to bed until it goes, and allowed up only very cautiously. Severe headache that persists in spite of rest in bed for several weeks or recurs inveterately on the resumption of active life calls for and is usually completely curable by a simple decompression operation.

III. Pathology, Clinical Features, and Treatment of Contusion and Laceration

Pathology.—The distinction between contusion and laceration cannot be satisfactorily enforced, so that for practical purposes the two conditions may be dealt with as one. The effects of such lesions may be enumerated as follows:—

(*a*) Direct effects on the function of the contused part.

(*b*) Hæmorrhage from torn vessels.



Direct and polar contusion of the brain.

As far as could be ascertained the patient had simply fallen on the back of his head in the street. The direct contusion about the cerebellum and medulla is relatively slight. The indirect contusion at the frontal pole is very extensive, and has caused a large hæmorrhage. A large hæmatoma is present beneath the lacerated frontal lobes.

PLATE 126.

Œdema of the contused part.—The occurrence of œdema is probably the commonest complication to which are liable all morbid conditions of the brain, whether traumatic, inflammatory, or neoplastic. It is quite likely that the brain is not more liable to œdema than any other organ, but its situation within the skull makes it sensitive to an amount of œdema which would produce no effect elsewhere. There is no room in the skull for œdema; all the available space, with a very narrow margin, is needed for the brain and the satisfactory functioning of its blood supply. As soon as a given part of the brain becomes œdematous the circulation of the blood through it is threatened and, according to the severity of the condition, more or less impaired. This impairment takes the form of impeding the circulation in the veins, and so causing venous congestion. From the nature of the case it is obvious that the pressure of the œdema fluid will tend not to rise above that within the vessels from which it is derived. Consequently, the pressure of it will not be enough to cause actual anæmia of the brain substance, at any rate in the non-inflammatory forms of œdema with which we are now concerned. Pathological considerations, therefore, bring us to the important practical conclusion that *symptoms due to œdema alone are irritative rather than paralytic.*

Œdema may develop in consequence of any injury to the walls of the cerebral vessels. Of such injuries the most important are *contusion, prolonged closure from pressure,* and *inflammatory processes.*

The form which follows contusion tends to develop fully within about forty-eight hours from the injury. No similar limit can be placed on its persistence, and its manifestations may last for many weeks after the accident. In such cases no doubt it is maintained by the presence of much gross contusion, and possibly hæmorrhage as well.

The œdema following a contusion may, to a certain extent, spread into [illegible] causes pressure upon, and [illegible] this in turn leads to further [illegible] however, that the process tends to diminish in intensity away from the primary focus, and that in an otherwise healthy brain a really extensive spreading œdema does not develop from a single localized lesion. Contusion of the brain is, however, very rarely a single isolated lesion. The multiple foci of contusion which are present in any fairly severe case can, no doubt, give rise to a practically general œdema of the brain. When a patient is suffering from œdema of the brain following contusions the symptoms may be expected typically to indicate *a widespread disturbance of moderate intensity.*

Clinical features. "Cerebral irritation.—Owing to the variability in the site and extent of the lesions, contusion does not produce a single characteristic clinical picture. Such symptoms as are produced are due either to the direct damage of the contusion impairing the function of some part or parts of the brain, or to the *secondary œdema* which develops. The primary symptoms are not usually well defined or focal. They appear most commonly as complications in the course of *concussion. Great prolongation* of the collapse stage with slow and irregular recovery from it may generally be taken to indicate that considerable direct damage to the brain has been inflicted, especially in the subtentorial regions. The symptoms of secondary œdema following contusion are much more definite. They constitute the state which has long been known as "*cerebral irritation.*" This term, though admirably descriptive of the clinical condition, is somewhat misleading, in that it is apt to suggest that the contused brain is actually irritated by the injury of its substance and the extravasation of blood into it. The evidence is strongly against such a view. As we have already seen, the actual *underlying condition is a diffuse or even generalized œdema which* leads to an interference with the venous circulation and consequent increased excitability of the brain. This view is in accordance with the mode of development, the character of the symptoms, and the stability of the condition.

The patient, after recovering from a state of concussion which will usually have been unduly prolonged, passes into a condition resembling a greatly exaggerated stage of reaction He lies on his side with all his limbs flexed and his eyes protected from the light. All interference or stimulation is evidently painful, and if persisted in is apt to be resented. Thorough examination is therefore impossible, *or only to be carried out with the utmost gentleness* and consideration. The patient complains of severe throbbing headache, dizziness, and nausea. The headache is increased by bright light, loud sounds, movement, or mental effort. Repeated vomiting may occur, especially in children.

The mental condition usually shows slowness, drowsiness, and want of initiative. There is, however, no definite confusion. If left alone the patient lies motionless and silent. At night, however, he may become delirious. The regular alternation of drowsiness by day and *delirium by night is quite common in these cases.* If persistently roused the patient may fall into formidable accesses of rage.

The temperature is usually slightly raised, the face flushed, and the pulse full. If the bulb is much affected by the œdema the pulse-rate is apt to be slow, and there may be disturbances of respiration (slowing and deepening or periodicity).

The condition usually reaches a maximum in forty-eight hours from the accident. It may persist for several days, or even a week or two, and then gradually subside. Residual symptoms are much commoner in these cases than after simple concussion.

The course may be interrupted by some complication, such as hæmorrhage or an infection. The localized subdural hæmorrhage is the commonest of these.

The mental symptoms are apt to show considerable variation. The irritability may develop into active continuous delirium. Such an occurrence should always suggest that some more serious cause of compression than mere œdema is developing—generally a slow hæmorrhage. Delirium may persist and be gradually modified into a definite insanity. The latter tends to recovery after some weeks, or even months, but may become permanent.

Diagnosis and prognosis.—The condition itself is characteristic. The chief task of diagnosis is to watch for evidence of complications such as hæmorrhage In ordinary cases recovery is the rule, but there is an especial liability to incomplete recovery, leaving such residual conditions as headache, loss of memory, giddiness, changes of disposition, and traumatic neuroses.

Treatment.—This should be the same as that of the reaction stage of concussion (*see* p 472) When the symptoms are severe and persistent, operative treatment (decompression) should be considered. Decompression not only relieves the symptoms rapidly but tends to allow of a subsidence of the œdema which causes them Moreover, at operation slight shallow hæmorrhages are often found on the surface of the brain and can be removed. Probably the residual symptoms so often left in these cases would be much less frequent if decompression operations were more commonly done. Persistent delirium is a symptom which should always cause the question of operation to be raised.

Unresolved contusion.—The tendency of any contusion of the brain to persist indefinitely and to cause a characteristic form of headache has already been referred to in dealing with the sequelæ of concussion. It is necessary here to point out further that when strictly localized violence is applied to the skull there may be no immediate evidence that any serious injury has been inflicted and yet a contusion may be produced that is capable of causing severe and persistent symptoms later on A typical form of such an injury often results from a glancing blow by a rifle bullet. There is usually then no definite concussion, there is often no obvious fracture of the skull and even no complete division of the scalp, but the patient finds himself rendered quite unfit for active life through typical contusion headaches. The significance of these cases is still too often overlooked.

When the condition is capable of definite diagnosis a local decompression over the contused area should be done and is almost always completely successful. At the operation it will often be found that a fracture, possibly with depression of the inner table, is present though it has previously given no direct signs of its existence. Moreover, the brain will show distinctly recognizable evidence of persistent contusion.

TRAUMATIC INTRACRANIAL HÆMORRHAGE—TRAUMATIC COMPRESSION OF THE BRAIN

The most important consequence of head injuries is intracranial hæmorrhage. Hæmorrhage within the skull produces a gradual encroachment on the intracranial space, and therefore tends to compress the brain and disturb its blood supply. To this ingravescent interference with the circulation of the brain the term "compression" has been especially applied; it is used to describe, on the one hand, the pathological processes at work, and, on the other hand, the corresponding clinical manifestations. Unfortunately, however, the term is frequently limited to a certain clinical picture which is very common in severe or neglected cases Of this picture the principal features are coma, unequal pupils, stertorous respiration, slow pulse, and high blood-pressure. To such an extent has the term been limited to this condition that even to-day it is sometimes believed that a diagnosis of compression of the brain cannot be made in the absence of these supposedly cardinal symptoms. In reality, the state of compression indicated by this clinical picture is a very advanced one. Changes in the pulse, respiration, and blood-pressure can be produced only by interference with the circulation in the medulla oblongata, and if the surgeon waits for reasons of diagnosis until, for example, the so-called "compression pulse" has appeared, he will have allowed the disturbance to extend to the most vital region of the brain, and will have added not a little to the patient's danger. In actual practice it is quite unusual for bulbar symptoms *of late onset* to be of any diagnostic value. The term compression, therefore, should be used pathologically to indicate a gradually increasing interference with the circulation of the brain, and clinically to indicate the consequent interference with function of whatever sort. What the actual symptoms may be depends upon what part of the brain is most seriously implicated. It is convenient to limit the term traumatic compression to the effects of hæmorrhage resulting from injury, though similar conditions are occasionally produced by other mechanisms, such as œdema or localized infective lesions with or without hæmorrhage. Non-traumatic cerebral hæmorrhage, as might be expected, frequently produces a condition of compression closely similar to the traumatic form.

Pathological anatomy.—The important anatomical varieties of traumatic intracranial hæmorrhage are as follows:—

1. Extradural.
2. Intradural—(*a*) diffuse, (*b*) localized.
3. Intracerebral

1. Extradural hæmorrhage (meningeal hæmorrhage) is the most familiar form, though probably not the most frequent, and is a common cause of the classical picture of traumatic "compression." In order that an extravasation should be possible in this situation, it is necessary for the pressure of the escaping blood to be adequate to detach the dura from the bone. In consequence, the hæmorrhage is delayed by conditions of collapse (concussion), and occurs in any case at a relatively slow rate. Moreover, the distribution of the hæmatoma is also influenced. The adhesion of the dura being most marked at the base tends to limit the extension of the blood in this direction. Antero-posterior and upward extension is not thus limited.

The middle region of the lateral part of the cranium is the most common situation of the hæmatoma. The temporal fossa indicates roughly the area of skull on the deep surface of which the bulk o the extravasated blood will be found. Several varieties of this hæmatoma have been described according to the branches of the middle meningeal artery from injury of which they are supposed to arise. Such classifications are, however, of little practical value.

The source of these hæmorrhages has been generally taken to be the middle meningeal artery. Doubtless in many cases this is correct. It is probable, however, that the bleeding often comes from injured veins. The frequency with which the temporal part of the skull is the seat of the hæmatoma would be consistent with either view, as the large spheno-parietal sinus is especially exposed to injury from its situation in a deep groove or incomplete canal in the bone.

Hæmorrhage from the large sinuses of the dura is very rarely of extradural distribution. Such hæmorrhage generally finds an easier path externally when the sinus is punctured by bone, or intradurally when the sinus is ruptured.

Extradural hæmorrhage in the frontal and occipital regions is comparatively rare, but less so in the former than the latter. Meningeal hæmorrhage is usually due to a fracture traversing the temporal fossa. Through such a fracture blood frequently escapes from the hæmatoma into the external soft parts. In children true extradural hæmorrhage is decidedly uncommon, because from the firmness of the adhesion between skull and dura the latter is much more frequently torn with a fracture than in the adult, and consequently the bleeding finds an entry into the subdural region.

The majority of meningeal hæmorrhages of any size prove fatal

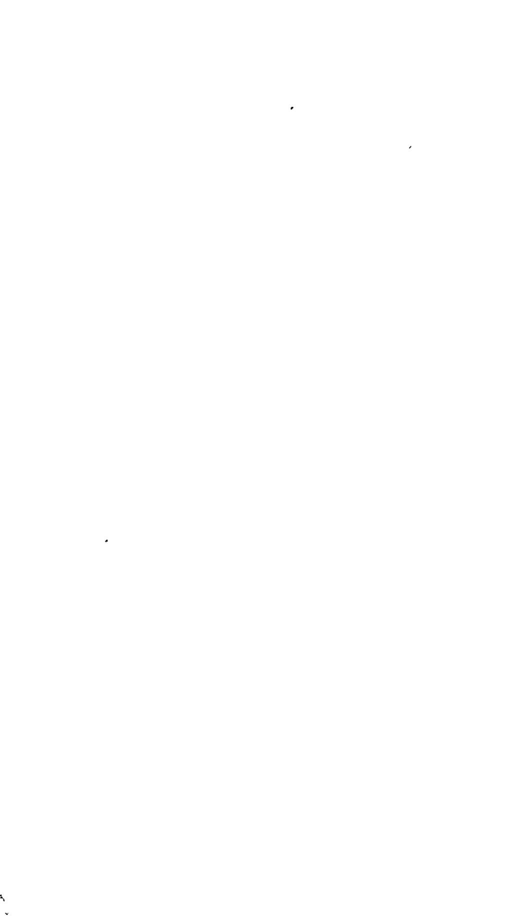
if left untreated. Occasionally the patient may survive, and th extravasated blood be converted into a fibrinous mass which i absorbed slowly or not at all. There is little or no tendency to cyst formation.

2. **Intradural hæmorrhage.**—Two well-marked types are t be recognized according to the extent of the hæmorrhage, viz. th diffuse and the localized. In one or other form the condition is on of the commonest complications of head injuries. The blood ma come from—(*a*) large arteries, such as the internal carotid or middl cerebral; (*b*) the large venous sinuses; (*c*) the cerebral veins wher they pass from the surface of the brain to the dura.

In (*a*) the hæmorrhage extends rapidly, and is usually so soo fatal as to be of little clinical interest. The blood spreads over th hemisphere of the same side and along the base; entering the posterior fossa it tends to surround the medulla and to cause death by pressure on the floor of the 4th ventricle. In (*b*) and (*c*) the hæmorrhage may be limited in amount and the extravasation localized, or it may be extensive and diffuse. Probably the size of the ruptured vessels is the most important factor in determining which form of extravasation develops In many cases the course of the symptoms suggests that the hæmorrhage has ceased temporarily and then broken out again. Such temporary arrest may be due to circulatory weakness, to clotting within ruptured vessels, or to mere contact of the brain with the opening in the vessel. Experience derived from operations shows that the very least pressure on a torn cerebral vein will arrest bleeding from it. Recurrence of hæmorrhage may follow any increase in the blood-pressure, and especially in the venous pressure. Increases in venous pressure are produced by any action accompanied by straining, such as vomiting, defæcation, etc. In the early stages the act of vomiting is often seen to usher in a marked increase in the symptoms of compression.

Recurrence of hæmorrhage may occur within the first few hours or be delayed for days. In some cases the symptoms suggest that there have been several recurrences of hæmorrhage. The localized form of hæmorrhage usually remains limited to an area of brain surface 3 or 4 in. in diameter, or even less. At operation it frequently appears to be beneath the arachnoid. All stages between mere bruising and a definite collection of extravasated blood are found.

In the diffuse form the blood extends widely over the hemisphere. If the process continues the blood reaches the base, where it will extend across the middle line and downwards into the posterior chamber of the skull. Spreading here round the medulla, it will ultimately press on the centres in the floor of the 4th ventricle and cause death. The blood over the hemisphere may accumulate to



the amount of many ounces, and, although of venous origin, under considerable pressure, so that when the dura is punctured a jet may spurt out to the height of 6 or 8 in. Such a collection displaces the brain towards the opposite side, wedging the corpus callosum and adjacent part of the brain into the opening of the falx. This opening may be so tightly sealed up that very little of the abnormal pressure is communicated to the opposite half of the cranial cavity, and it is very unusual for blood to find its way under the falx to the opposite hemisphere. Such spread across the middle line as occurs is at the base. Hæmorrhage over both hemispheres is thus practically always due to a bilateral lesion.

Bilateral hæmorrhage.—This is sufficiently common to demand especial notice. From what has already been said in discussing the mechanism of contusion it will be understood that any considerable blow on one side of the head is practically certain to produce bruising on both sides of the brain. It follows, therefore, that when the bruising on one side has been severe enough to cause hæmorrhage, the chances are considerable that a hæmorrhage on the other side has been produced. Actual experience thoroughly bears out this inference, and there is no commoner cause of disappointment after an apparently successful operation for intracranial hæmorrhage than the presence of a similar lesion on the other side. There may be a great disproportion in the size of the two hæmorrhages, and it is by no means always the case that the larger causes the more definite localizing symptoms

Changes in the extravasated blood. Traumatic subdural cysts.—Absorption, no doubt, can occur when the hæmatoma is small Extravasation in the form of a thin film of blood over a considerable area is probably very common in head injuries. Such collections are doubtless completely absorbed. Large hæmorrhages, as a rule, persist and, if they do not cause death quite soon, become encysted. (Plate 127.)

The cyst wall seems to consist of fibrin deposited at the periphery of the hæmatoma In the course of a few weeks a very definite and tough membrane may have formed. This can sometimes be stripped off the dura on the one hand, and the brain on the other, leaving the surfaces apparently normal. The surface of the cyst in contact with the dura is usually adherent to it, though not very firmly. The contents of the cavity consist within the first few weeks of altered blood-clot and dark-coloured fluid, usually of a greenish tint. Later the blood pigment may largely disappear, and masses of cholesterin crystals be found. These hæmorrhagic cysts have a remarkable tendency to increase in size even without further hæmorrhage, and may at long periods after the accident give rise to symptoms, such as optic neuritis, suggestive of cerebral tumour.

3. *Intracerebral hæmorrhage.*—Two forms are recognizable, that which occurs immediately upon the accident and that which occurs remotely as the result of softening in the brain substance. Both are uncommon.

Secondary rupture on to the surface or into the ventricle, according to the situation of the hæmatoma, is relatively common.

Cyst-formation is frequent if the patient survives the immediate effects of the hæmorrhage.

Traumatic ventricular cysts.—Occasionally such cysts communicate with the lateral ventricle. This is especially likely to occur in children, in whom much severer cerebral injuries are recovered from than in adults. In one such case on which I operated the cyst presented through a gap in the skull as a fluctuating swelling under the skin It was found to occupy at least a third of the bulk of the hemisphere, and in its deeper part the choroid plexus of the lateral ventricle could be seen Cysts of this kind are most common as the result of head injuries received during birth.

Intracranial hæmorrhage of the new-born.—It is only comparatively recently that the head injuries to which the child is liable during birth have received due attention from surgeons. The frequency of intracranial hæmorrhage in the new-born has been observed in several long series of autopsies. The results have differed considerably: some observers have found hæmorrhage in 2 per cent. of all post-mortem examinations of young infants; others in as many as 12 or 13 per cent. It is certainly far from an uncommon injury, and it must be remembered that probably a large number of infants recover from it with or without persistent symptoms. The frequency of the so-called congenital and infantile hemiplegias and diplegias confirms this view.

The commonest lesion is a subdural hæmorrhage. Laceration of veins entering the longitudinal sinus and laceration of the tentorium are the chief sources of the bleeding.

The mechanism of these injuries cannot be discussed here. It may be stated, however, that difficult labour and instrumental delivery are common antecedents, but that abnormally quick labour and even delivery by Cæsarean section have been followed by it.

The hæmorrhage usually comes on and causes symptoms within a few hours of birth, but it may not become manifest clinically for several days, or possibly even weeks. It is probable that many cases of convulsions occurring within a few weeks of birth are due to traumatic lesions of the brain The new-born infant's brain is very tolerant of compression, and consequently symptoms are apt to be slight or obscure. Definite localizing symptoms are frequently, perhaps usually, absent.

The tendency to hæmorrhage not uncommonly present, especially in syphilitic infants, is probably an important factor in many cases. It should be remembered in considering the prospects of operation, as it may cause the patient to bleed to death after the hæmatoma has been evacuated.

It is probable that energetic artificial respiration often leads to hæmorrhage from injuries which would have proved comparatively harmless otherwise.

Symptoms of intracranial hæmorrhage.—Intracranial hæmorrhage is always a local lesion, that is to say, it always affects some part of the brain more than the rest. A great variety of clinical pictures is therefore possible, according to the situation of the hæmatoma. Even when the latter is very large, and its effects are correspondingly widespread, the increase of intracranial *pressure is never general and uniform throughout the skull. The use* of the term "general compression" is therefore scarcely to be justified even in very advanced cases, since it is apt to be understood as implying that the pressure is uniform as well as widespread.

It is convenient to describe the symptoms in groups according to the regions of the brain by interference with which they are produced. Of such groups are to be recognized hemispheral symptoms, midbrain symptoms, and bulbar symptoms. In each group the symptoms will be divisible into irritative and paralytic—the irritative corresponding with the presence of venous congestion or stasis in the affected part of the brain, and the paralytic with the presence of anæmia.

It will be convenient first to enumerate the chief symptoms in tabular form, and then to add what comment is necessary.

HEMISPHERAL SYMPTOMS

	IRRITATIVE	PARALYTIC
Consciousness	Irritability. Delirium. Slowness. Drowsiness.	Coma.
Motor cortex and pyramidal tract	Rigidity. Jacksonian fits	Hemiparesis. Hemiplegia. Exaggerated reflexes. Babinski's sign. Loss of abdominal reflex.
Area of Broca		Aphasia.
Occipital lobe		Hemianopia.

Certain symptoms do not point to any particular part of the brain:

Headache, which is probably always due to stretching of the dura or dural processes.

Giddiness and other abnormal sensations referred to the head, which may occur with any disturbance of the hemispheres.

Generalized convulsions, which indicate very rapidly increasing pressure, such as that due to ventricular extension of a hæmorrhage.

Word-blindness and *word-deafness* are rarely distinguishable on account of the general disturbance of consciousness. In very slow localized hæmorrhages one or other may occur, and then is of localizing value.

Hallucinatory sensations of sight, sound, and smell are probably common at the onset of lesions of the occipital, temporal, or anterior temporal regions respectively, but they are transient, and confused by oncoming disturbance of consciousness.

MIDBRAIN SYMPTOMS

	IRRITATIVE	PARALYTIC
Oculo-motor nucleus .	Contracted and sluggish pupil.	Dilated and fixed pupil

BULBAR SYMPTOMS

Respiratory centre .	Deep, slow breathing.	Shallow, gasping, irregular breathing.
Cardiac centre . .	Slow, full pulse.	Rapid, small, weak pulse.
Vaso-motor centre .	Rising blood-pressure.	Falling blood-pressure.

Vomiting is apt to occur in all brain lesions. It is probably always of bulbar origin, but is not of great significance as a symptom of onset. When persistent it probably always indicates definite involvement of the bulb.

Glycosuria usually indicates bulbar involvement. It comes on within a few hours and is transient. It may also be due to injury of the pituitary body.

Full discussion of the various symptoms enumerated in this table is not possible here, but some aspects of them must be dealt with briefly.

Affections of consciousness.—The relation between impairment of cerebral function and impairment of consciousness cannot be stated in very definite terms. In a general way it may be said that a large surface of cerebral cortex, probably one-half to two-thirds of one hemisphere, must be affected before consciousness is much impaired. The rate at which the cortical disturbance comes on is, however, quite as important a factor as is the extent of it. Three fairly definite types of affection can be differentiated by clinical observation.

(*a*) Rapidly developing pressure over a large part of one hemisphere which is intense enough to produce anæmia causes profound coma.

(*b*) Rapidly developing pressure over a similar area of such a grade as to produce venous engorgement leads to an "irritative" modification of consciousness. Such a stage is passed through in the early period of all large intracranial hæmorrhages. *The patient*, at first irritable, rapidly becomes excited and [illegible] violent; he shows little or no mental confusion, but is apt to [illegible], aggressive, and resentful. The state is often *absolutely* [illegible]*able from*

alcoholic excitement, for which it is frequently mistaken with lamentable results Just as with alcoholic excitement, the condition readily passes into maniacal delirium. The patient, though quite impervious to argument or persuasion, seems so fully conscious and wilful that he is apt to be handed over to the police as merely drunk. In these well-marked cases the hæmorrhage is always large, so that coma usually supervenes within an hour or two, commonly enough in the police cell to which the unfortunate patient has by that time been conveyed. These mistakes are still made because it is supposed that the differential diagnosis of alcoholism and cerebral hæmorrhage *is a matter of distinguishing two forms of coma.* In actual fact there is hardly ever any difficulty when the patient is comatose, whereas the two forms of delirium are often *identical* and can be distinguished only by keeping the patient under observation.

(c) Very slowly developing pressure, though it may be widespread and severe, causes a very different picture. The essential features are the *slightness* and *variability* of the symptoms. Dullness and drowsiness of moderate grade without much confusion, often with restlessness or mild delirium at night, are the usual changes in consciousness. Occasionally there may be quite definite intermissions in the symptoms. It is surprising how large a hæmorrhage may accumulate, if only its increase is slow, without any marked mental change being noted by the patient's friends. Finally, of course, the limits of compensation are reached, and then profound changes rapidly appear.

Affections of the pupil.—Definite pupillary changes appear late, unless the primary lesion is close to the midbrain, and are evidences of serious pressure. The nuclei of the two sides, being close together, tend both to be affected, but the changes in the pupil on the side of the lesion always remain in advance of those in the opposite pupil. Suppose, for example, there is an increasing hæmorrhage pressing on the right hemisphere, the various changes may be as follows :—

	RIGHT PUPIL	LEFT PUPIL
Irritative symptoms on side of lesion	Contracted and sluggish.	Normal.
Early paralytic stage on side of lesion, irritative on opposite side	Slightly dilated and fixed.	Contracted and sluggish.
Paralytic stage both sides, more marked on side of lesion	Dilated and fixed, but larger than left.	*Dilated and fixed.*

Bulbar symptoms.—Of the great vital centres in the bulb, the respiratory is the most sensitive to pressure and the vaso-motor the least sensitive. In any case of increased intracranial pressure

the respiratory centre may pass into the paralytic stage with rapid cessation of respiration. This is the only paralytic bulbar symptom due to compression from which recovery can be attained by treatment. If the bulbar pressure can be relieved while artificial respiration is kept up, the patient may be saved. Paralysis of the vaso-motor centre as a result of compression is necessarily fatal.

For these reasons the appearance of the classical (irritative) bulbar symptoms should always be regarded as very serious, and should be anticipated by treatment whenever possible.

The vaso-motor centre responds to pressure in a way which demands further notice. As soon as the pressure seriously impedes the circulation through the bulb, a remarkable activity of the centre is aroused. As a result of this, and through the means of constriction of the vessels of the splanchnic area, the blood-pressure rises, so that it can again force an adequate blood supply through the compressed vessels of the bulb. If the intracranial pressure rises still higher so as to exceed the blood-pressure once more, a further splanchnic vaso-constriction raises the blood-pressure again until it can once more overcome the resistance in the vessels of the bulb. This remarkable mechanism, whereby the vaso-motor centre protects the bulb against the effects of compression, is the "vaso-motor reaction" of Cushing. It explains completely the meaning of the high blood-pressure which has long been known to occur in many cases of cerebral compression. In such conditions the pressure may double its normal height and reach 300 or even 400 mm. Hg. It becomes clear, moreover, that the high pressure is essentially protective, and that any attempt to reduce it directly without removing its cause is not merely useless but dangerous.

The reaction of the vaso-motor centre is not always to cause a steady rise of blood-pressure. In some cases, from causes which are not known, the vaso-motor response is periodic. When this happens there are periods during which the blood-pressure is high and the bulbar circulation is adequate, alternating with periods in which the centre is inactive, the blood-pressure low, and the bulbar and general cerebral circulation deficient. Thus is produced the Cheyne-Stokes phenomenon, which is in essence a perfectly regular rhythmic alternation of periods of activity and inactivity of the brain. During the periods of inactivity the patient lies like one dead, with no movement even of respiration; during the periods of activity the most striking features are the strong and deep respiration and the evidences of restored function of the cerebrum, such as movements of the limbs, groaning, muttering, or even consciousness.

In cases where the phenomenon is due to a hæmorrhage in the superior chamber, restoration of consciousness is never complete,

and movements of the limbs are the chief evidence of the temporary restoration of function. Such movements are usually purposive in character, and are apt to become stereotyped, so that at each period of activity the patient goes through exactly the same series. This machine-like repetition of the same action every few minutes for possibly a period of two or three days is very striking and characteristic. Such movements never affect limbs which are hemiplegic from pressure of the hæmorrhage. Their recurrent and automatic character may cause them to be mistaken for Jacksonian fits. This is a serious error, as it leads to the skull being opened on the side opposite to the hæmorrhage

The Cheyne-Stokes phenomenon is sometimes regarded as a terminal symptom. This view is not fully in accord with the evidence. The phenomenon is certainly a late symptom, just as is the continuously high blood-pressure which is the more common mode of response of the vaso-motor centre. It is not terminal, however, in the sense of being a later stage of the ordinary vaso-motor reaction, but is rather an alternative to this latter, and when it occurs is the primary response of the centre to compression.

The Cheyne-Stokes phenomenon is carefully to be distinguished from the *irregular*, gasping respiration which is truly terminal in character, and indicates the onset of paralysis of the bulb.

Clinical types of intracranial hæmorrhage.—The symptoms of hæmorrhage appear in a variety of combinations practically infinite. Certain types, however, can be selected which present a reasonable degree of stability and are usually accessible to diagnosis. The chief of such will be given, but it must be remembered that only typical cases are considered.

1. Extradural hæmorrhage. Meningeal hæmorrhage.—A fracture traversing the temporal fossa, and usually the base of the skull also, is present. Blood escaping through the fracture may infiltrate the temporal muscle and cause an œdematous thickening which, in the absence of evidence of local external injury there, is of diagnostic value. Concussion is usually well marked. When it passes off the patient recovers, to all appearance completely. He will be fully conscious, able to speak normally, and possibly to move, walk, or even run with full strength.

That a case of compression has shown this lucid interval is always very suggestive of extradural hæmorrhage. It may last from half an hour to twenty-four hours, or even more. During it the patient frequently suffers from severe headache and from giddiness, and may vomit. The less the patient exerts himself the longer the interval is likely to last.

Generally within an hour or two after recovery from concussion

the headache increases greatly in severity and the patient becomes irritable and drowsy. The irritability may, but does not usually, develop into delirium; then the drowsiness increases to profound coma.

Evidences of hemiplegia appear on the opposite side to the lesion, viz. drooping of the face, flabbiness of the cheek, flaccidity of the limbs, exaggeration of deep reflexes, Babinski's sign, and disappearance of superficial abdominal reflexes.

These signs are preceded by rigidity, twitchings, and possibly Jacksonian fits.

As the hemiplegia comes on the rigidity passes off and the limbs become flaccid. By the time the hemiplegia is established the limbs on the other side, i.e. on the side of the lesion, have become rigid.

If the hæmorrhage is on the left side, the patient may be noticed to be aphasic before the coma has developed.

The pupil on the side of the lesion is first contracted and then dilated and fixed. Similar changes follow later in the other eye.

By the time pupillary changes have appeared the bulbar symptoms will usually be developing, and there will be slow stertorous respiration, slow pulse, and high arterial tension. If left untreated the patient dies from paralysis of the bulbar centres.

2. **Diffuse acute subdural hæmorrhage.**—Evidence of fracture is not so common as in meningeal hæmorrhage, and is of less diagnostic value.

Concussion is usually severe, and the interval between it and the onset of compression symptoms is absent or very short. Sometimes the vomiting which indicates recovery from concussion seems to precipitate the onset of the compression.

Well-marked mental symptoms are usual; the patient is often unruly and violent, and sometimes maniacally excited. This condition lasts at the most for a few hours, and is succeeded by the profoundest coma.

Hemiplegic pupillary and bulbar signs follow in due course as in meningeal hæmorrhage, but the evolution of the case is characteristically much more rapid. Bulbar symptoms especially are likely to be of early onset and severe. Hemiplegic signs are very unlikely to be detected before the onset of coma.

3. **Localized subdural hæmorrhage.**—This is essentially a subacute condition. After the concussion has passed off reaction is severe, and is apt to be followed by evidences of slight widespread compression—so-called "cerebral irritation." After this has persisted for some days, or possibly even a week or two, and shown a tendency to increase rather than to diminish, signs of localized compression of a severer grade appear rather suddenly; most commonly these take the form of Jacksonian fits, indicating that

the hæmorrhage is in or about the motor cortex. Occasionally the localizing sign may be aphasia, hemianopia, or what not, according to the seat of the lesion.

4. **Chronic subdural hæmorrhage.**—These cases run a prolonged course of several weeks, or possibly even two or three months. This course is divisible into a long prodromal period in which the symptoms are slight, ambiguous, or misleading, and a short period during which serious symptoms rapidly develop and the presence of a definite widespread compression becomes manifest.

The accident may be severe, slight, or even apparently trivial. The patient recovers from the immediate effects, but either does not get perfectly well or soon develops slight symptoms. The characteristic of such prodromal symptoms is their variability from time to time.

Headache and giddiness are common, and tend to occur in attacks of increasing severity, Sometimes agonizing headache is the principal trouble.

Mental changes are perhaps the commonest disturbance. Changes of disposition, attacks of irritability, lethargy, and loss of initiative, are among the slight manifestations. There may also be transient attacks of mental confusion or of unconsciousness, possibly so slight as not to arouse serious attention. Persistent drowsiness, with perhaps mild delirium at night, occurs in some cases.

It is unusual for definite physical signs of compression to be present, but such may come and go in a very surprising and puzzling way. At one examination an alteration of reflexes of hemiplegic type may be found, while the next day no such abnormality can be discovered. The same perplexing alternations may occur between coma and normal consciousness. After several hours of coma which has every appearance of being terminal the patient may suddenly wake up and even be able to get out of bed, only to relapse into coma again a few hours later. This fluctuation of consciousness may be repeated two or three times, and is then extremely characteristic Occasionally the mental state passes into the wakeful irresponsiveness of a dementia. Often a fullness of the retinal veins on one side is found, and as a rarity definite optic neuritis.

After a variable period of these symptoms the headache may suddenly increase, vomiting occur, the drowsiness deepen to coma, and definite evidence of hemiplegia be found. The hæmorrhage is usually over the middle part of the lateral aspect of the hemisphere, and in a number of cases is bilateral. When it is chiefly anterior or posterior, corresponding modifications of the signs both in the prodromal and the acute stages may be present.

At the time of operation the hæmorrhage is generally found to

be definitely encysted, as already described. There can be little doubt that the condition referred to by pathologists [illegible] haemorrhagica interna is a traumatic [illegible]

5. **Delayed hæmorrhage.** [illegible] cases the patient to all appearance recovers completely from the accident, which is often trivial. Some weeks later, generally two or three, there is a sudden onset of symptoms of severe compression; not uncommonly the hæmorrhage ruptures into the ventricle, causing high fever, general rigidity, and convulsions. In any case the outlook is always serious, and most often a fatal end rapidly ensues.

6. **Subtentorial hæmorrhages.**—In all the varieties described above the hæmorrhage occurs in the superior chamber of the skull in the great majority of cases. Hæmorrhage into the inferior chamber is rarely observed clinically, because, on account of the restricted space there and the concentration of function in the bulb, the condition is rapidly fatal. In rare cases, however, it is to be seen clinically. The remarkable picture produced is so important that it must be briefly mentioned. Bulbar symptoms are manifest from the first. There will be stertorous slow respiration, full slow pulse, and high blood-pressure. Vomiting is also common. In spite of these symptoms, so closely associated with the classical picture of compression, the patient may be perfectly conscious. In other cases the Cheyne-Stokes phenomenon is present, and then the patient is conscious during the active periods and unconscious in the intervals The condition is dangerous to the last degree, and usually ends very soon in death.

Diagnosis of intracranial hæmorrhage.—The problems presented by this subject are frequently complex and difficult, and sometimes insoluble. This fact should not, however, discourage the surgeon from attempting to make a reasoned and complete diagnosis in each case. There is no part of the body in which the relation between lesion and symptoms is more precise, and none where a thorough grasp of physiological and pathological principles can be used more fruitfully.

The chief source of difficulty is the fact that any severe head injury tends to produce lesions which are not only multiple but also of different intensity and importance. Moreover, it is not necessarily the most important of these which produces the most obvious signs, so that the accurate diagnosis and adequate treatment of a single lesion may leave the patient in danger from some other unsuspected condition.

It is necessary, therefore, not merely to depend on the actual symptoms and physical signs shown by a given case, but also to take into consideration the probable effects on the intracranial contents

of the kind of violence which has been sustained. The former may be referred to as the direct evidence, the latter as the indirect.

Indirect evidence. 1. *The nature of the force applied to the skull.*—Sharply localized blows (stab wounds, pistol shots of low velocity) tend to cause marked local injury only, and but little concussion or general and distant contusion. Blows of large objects or falls on the head tend to cause much concussion and distant and widespread contusion. High-velocity bullets produce much local injury about the track of their passage, and may cause widespread bruising from their explosive action.

2. *The direction of the force applied to the skull* may give valuable evidence as to where contrecoup injuries may be expected. It should always be remembered that the principal or even the sole hæmorrhage may be on the opposite side to that struck, and that the hæmorrhage may be bilateral.

3. *The general severity of the accident* should be taken into account. Accidents of great violence always tend to produce widespread and severe contusion, and this may be suspected in such cases even when the symptoms are relatively mild. In other words, if two cases be taken in which apparently similar injuries have been produced by accidents where the forces concerned have been of widely different severity—say a carriage or bicycle accident in the one case and a motor-car or railway accident in the other—it will generally be found that the latter case runs a more severe and complicated course, though the manifest injuries in the two are the same. Such considerations make it clear that it is very important for the surgeon to be familiar with the modes of distribution through the skull and brain of forces applied externally, and with the immediate effects of such disturbances upon the intracranial contents.

4. *The presence of fracture of the skull* is important as indicating a severe grade of violence and possibly the seat of the hæmorrhage, but it must always be remembered that for purposes of localization physical signs of brain injury are much more important than the situation of the fracture.

Direct evidence. 1. *The nature of the lesion.* (*a*) External evidences of intracranial hæmorrhage.—In cases of meningeal hæmorrhage effusion of blood under the scalp, if there is no evidence of local external violence, is a valuable sign. In children an important variety of extracranial escape of blood occurs. In such cases the dura and pericranium are torn at the line of the fracture, and a free exit is available for subdural effusions to escape. The blood finds way into and distends the subaponeurotic areolar tissue, forming a large hæmatoma. As long as the external escape is free there may be few or no serious symptoms of pressure on the brain. As soon,

however, as the scalp is tightly distended, further hæmorrhage will produce cerebral symptoms. Such a "safety-valve hæmatoma" is not uncommon in children, and the picture of a very large subaponeurotic extravasation associated after an interval of two or three days with cerebral symptoms is characteristic.

(b) Blood-staining of cerebro-spinal fluid as ascertained by lumbar puncture.—This is of value in many cases of subdural hæmorrhage.

(c) Signs of cerebral involvement.—The features characteristic of hæmorrhage, as distinct from other traumatic lesions, are the mode of onset, the progressive nature of the symptoms, and the presence of paralytic symptoms. These three features constitute the minimum on which a diagnosis of hæmorrhage can be based. The onset always shows an interval between the accident and the first appearance of paralytic symptoms. This interval in the case of meningeal hæmorrhage usually comprises the period of concussion and a greater or less time (half an hour to twenty-four hours in general) in which the patient appears almost or quite normal. In acute diffuse subdural hæmorrhage the interval is short and may include but little more than the period of concussion, the patient passing from the latter into an obviously abnormal condition in which marked irritative symptoms are present. In cases of chronic hæmorrhage the interval is characteristically long. When very long it is not of much value in distinguishing the extradural and intradural forms. When there is no interval the case is very unlikely to be one of uncomplicated extradural hæmorrhage.

The progressive nature of the symptoms is very important. The most obvious evidence of progress is the passage of irritative into paralytic symptoms, such as the transition of delirium into coma. This progress may lead to error if the disappearance of the irritative symptoms alone is noted and the paralytic symptoms which succeed do not attract attention.

Paralytic symptoms are undoubtedly the most important of all. Œdema alone cannot produce them, and direct injury will not show the delay characteristic of hæmorrhage. Among possible paralytic symptoms are hemiplegia or hemiparesis, monoplegia, aphasia, loss of pupillary reflex, hemianopia, alterations in the reflexes of the limbs and abdominal wall. Any one of them may be enough to settle the diagnosis. The only precaution necessary is to make sure that the paralysis in question is not due to a cranial nerve injury from a fracture of the base of the skull. Such evidences of nerve injury may have a delayed onset, and this is especially the case with facial paralysis due to implication of the 7th nerve in the temporal bone. This form of facial paresis or paralysis is to be distinguished from that due to hæmorrhage over the lower part of the motor area

by the fact that it implicates all the facial muscles (of the one side) equally.

2. *The side of the lesion.*—The two great difficulties in determining this occur when the lesion is bilateral and when the patient is unconscious. The former will be referred to under Treatment, and we are chiefly concerned here with the *diagnosis of hemiplegia in a comatose patient.* The chief points to be observed are as follows. On the paralysed side—

Flaccidity of limbs.

Failure of hemiplegic limbs to participate in movements provoked by painful stimulation.

Drooping of the mouth.

Puffing out of cheek during expiration.

Elevation of temperature (usually about 1° F. above non-paralysed side).

Abolition or reduction of abdominal reflex.

Exaggeration of deep reflexes and possibly ankle clonus.

Babinski's sign.

In the presence of Cheyne-Stokes phenomenon, non-participation of paralysed side in periodic movements of limbs.

Differential diagnosis of traumatic hæmorrhage.—Much attention has been given to the diagnosis of the later stages of traumatic hæmorrhage from other causes of coma. The chief of these which come into question may be divided into three groups:

(*a*) Narcotic poisons—alcohol, opium, carbolic acid.

(*b*) Toxic states—uræmia, diabetic coma, hyperacute febrile conditions, such as sunstroke.

(*c*) Non-traumatic cerebral compressive states—embolism, thrombosis, hæmorrhage, cerebral abscess, meningitis, hæmorrhagic tumours, ruptured aneurysm.

Most of these conditions are susceptible of positive diagnosis, and full discussion of them is superfluous in a surgical work. A few elementary observations alone are necessary.

Intracranial hæmorrhage has been mistaken for alcoholic intoxication probably more often than for anything else. The reason for this is that drunkenness alone of the non-traumatic causes of coma produces a well-marked stage of general cortical excitation before it causes coma. It cannot be too strongly emphasized that it is the delirium of compression rather than the coma which is the cause of mistakes. The two forms of delirium are practically identical, but it will generally be found that that of compression is more active, aggressive, and uncontrollable than that of alcohol. A man "fighting drunk" can generally be influenced to some extent

by an appeal of the right kind, whereas a man with an early diffuse subdural hæmorrhage is more often a dangerous and unapproachable automaton. The latter may, however, betray evidence of the intense headache which he almost necessarily has. In many cases the only safe course is to keep the patient under observation. The subsequent coma in the two cases shows similar differences—that of compression rapidly becoming profound and impenetrable, while from that of alcohol the patient can often be at any rate partially roused. The coma of compression, being practically always accompanied by other paralytic symptoms, is usually easy to recognize. Evidence of injury to the head is likely to be present in both cases and is not of much value.

In toxic states coma rarely comes on rapidly enough to cause a sudden fall with injury to the head. Diabetic coma is the only form likely to cause difficulty. Positive evidence of "acetonæmia" must be found before the diagnosis can be made. Mere glycosuria is almost equally common after severe head injuries, but is, of course, essentially transient.

In the non-traumatic cerebral vascular lesions there is usually no marked stage of excitation. The very early onset of extensive paralytic symptoms is in marked contrast with traumatic cases. A priori it might be supposed that a capsular hæmorrhage causing a fall and injury to the head would be indistinguishable from a traumatic lesion. In actual practice mistakes of this kind are not common. If followed by operation they should be rather favourable to the patient than otherwise.

Intracranial hæmorrhage, except in the chronic forms, is not often difficult to distinguish from inflammatory lesions. If a patient with a chronic hæmorrhage has also chronic middle-ear disease the surgeon is very likely to be misled, and with very serious results, for he will be tempted to open up the mastoid as a first step. This will increase greatly the danger of sepsis in a subsequent intracranial exploration. If there is the least doubt, the latter operation should be done first.

A cerebral tumour into which hæmorrhage has occurred may produce many of the appearances of a traumatic lesion. An examination of the fundus oculi, by revealing optic neuritis, may prevent a mistake.

In concluding the discussion of diagnosis, it may be remarked that the determination whether a given hæmorrhage is extradural, subdural, or intracerebral is relatively unimportant compared with the diagnosis of its side and its other relations to the brain. The extradural hæmorrhage is usually distinguishable by the marked interval of lucidity and, in adults, by the evidences of external

escape of blood through a fracture. The discrimination between subdural and intracerebral hæmorrhage is sometimes possible, but is always difficult and of comparatively little value.

Prognosis in intracranial hæmorrhage.—Extradural hæmorrhage is of relatively slight danger if treated early. Diffuse acute subdural hæmorrhage is very serious, and, indeed, usually fatal. This is not inherent in the nature of the condition, but is mostly due to defective diagnosis and late and timid operating. Intracerebral hæmorrhage, even if evacuated by operation, is usually fatal, because in such cases there is almost always severe and widespread damage to the brain.

Many cases of all varieties of hæmorrhage end fatally after the hæmorrhage has been evacuated. Such results are due sometimes to recurrent hæmorrhage, not uncommonly to a second hæmorrhage elsewhere which has been overlooked, but perhaps most usually to widespread contusion of the brain implicating the medulla and leading to respiratory and circulatory failure. Such lesions in themselves might not have been fatal, but the presence of compression, by throwing extra demands on the damaged medulla, has turned the scale against the patient. Other things being equal, the danger of a given case of hæmorrhage is in direct proportion to the age of the patient, the severity of the accident, and the rapidity of onset of the symptoms. The presence of bulbar symptoms is always serious; the development of paralytic bulbar symptoms is necessarily fatal, and the only contra-indication to operation when a diagnosis of hæmorrhage has been made.

Treatment.—Operation is the only treatment available. The primary object of the operation is to find and remove the hæmatoma In addition, it is necessary to provide an exit for further oozing of blood, and sometimes to allow for relief of tension due to œdema and contusion. The actual arrest of bleeding from visible vessels is rarely called for.

The details of each operation must be varied to suit the particular case, but certain general principles may be laid down.

The situation of the opening in the skull should be determined by the cerebral signs. Failing distinct guidance from these, the region at which there are evidences of external violence should first be explored. The osteoplastic flap operation should, as a rule, not be done in acute cases. It is more severe and difficult than the ordinary operation, it tends to limit the free escape of any fresh oozing that may occur, and it does not allow of free decompression if there is much persistent tension from œdema or contusion. In mild subacute and in chronic cases it may often be used with advantage. A *very large skin-flap* should always be made to allow of

extension of the bone-opening in any direction, and to permit a free decompressive opening being made if necessary. It is desirable that a margin of at least an inch be left between the edge of the bone-opening and the skin incision.

It should be remembered that in severe cases the blood-pressure is often very high, so that unless special precautions are taken a dangerous amount of hæmorrhage may occur during the cutting of the flap. The simplest method to avoid this is to make the incision in small lengths at a time and to pick up the vessels as they are divided.

Drainage is not usually necessary, and should be avoided as much as possible on account of the risk of infection.

A second operation is frequently necessary. The evacuation of a hæmatoma should be followed by a definite and persistent improvement in the symptoms. If such does not occur or is not maintained a reopening of the wound, or more probably an exploration of the opposite side, is indicated, provided the persistence or recurrence of symptoms is not due to failure of the bulbar centres.

Meningeal hæmorrhage.—The opening should be made in the temporal fossa, and should include the course of the anterior branch of the middle meningeal artery, as this may be the source of the hæmorrhage. *An opening about 2 in. in diameter at the least* is desirable. If, after the evacuation of the hæmatoma, the brain expands readily and strongly, the dura should be incised and the subdural space explored. Failure of the brain to expand generally indicates failure of the bulbar centres, and is a bad sign.

Diffuse subdural hæmorrhage.—In these cases it is especially necessary to make a very large skin-flap. The clot should be washed out with normal saline solution. If the brain bulges strongly into the opening a large decompression should be done. No attempt should ever be made to suture the dura. It is quite unnecessary, and tends to restrain escape of blood as well as the formation of a temporary hernia. Drainage is not usually necessary.

Intracerebral hæmorrhage.—A very large flap and a large bone-opening should be made. As soon as the dura is freely opened the hæmatoma tends to find its way to the surface and bulges or bursts through the cortex. It is well to flush out the cavity in the brain with saline solution, but drainage can usually be avoided.

Chronic subdural hæmorrhage.—These cases are suitable for the bone-flap method, as there is not usually much œdema of the brain after the relief of pressure. Failure of the brain to expand in longstanding cases is due rather to secondary changes in it than to general circulatory failure. It is a serious sign, but it sometimes happens that a brain which does not expand at all well at the operation does so satisfactorily in the next few hours. If there is any reason

to suspect that the hæmorrhage is bilateral it is absolutely essential for both sides to be explored at the one operation.

FRACTURES OF THE SKULL

A very great amount of attention has been given by surgical writers to fractures of the skull, and there has been a tendency to deal with the much more important subject of injuries of the brain as if these latter were to be regarded as mere complications of fracture There can be little doubt that the relative importance of fractures has been exaggerated, with the effect of interfering with the formation of a well-proportioned and practical picture of the whole subject of head injuries. The chief respects in which fractures of the skull are of practical significance are—(1) their liability to cause laceration of meningeal vessels; (2) their tendency to cause local injury to the brain through depressed and detached fragments; and (3) their liability to permit the access of infective material to the intracranial contents. In the diagnosis of injuries to the brain the presence of a fracture is of importance as a means of estimating the nature, direction, and severity of the violence to which the patient has been exposed. It must be clearly understood, however, that a fracture may be present without any serious brain injury, and that serious brain injury may be present without a fracture.

Mode of production of fractures.—The theory of fracture of the skull has been much discussed and is still the subject of controversy. Such discussion is of little practical value, and will be limited here to the laying down of a few elementary principles.

When the skull is struck a severe blow, the bone, not being absolutely rigid, yields to some extent If this bending is carried beyond a certain degree the bone cracks. The amount of angular bending of which the skull bones are capable without breaking is, of course, small, but it is clear that the sharpness of the angle produced in the bone is what determines the occurrence of a fracture, and that this must vary according to the nature of the blow. If the external violence is applied over a very small area, as by a pointed instrument or bullet, the yielding of the bone—being, of course, limited to the point actually struck—causes a sharp bending immediately around this point, with the production of a punctured or depressed fracture which is characteristically sharply localized. The absence of any widespread deformation of the skull in such cases explains the characteristic absence of concussion which so often leads to a serious injury being overlooked. The presence of marked symptoms of immediate cerebral disturbance in certain cases of bullet wound is explained by the explosive effects on the brain of the

passage of the bullet. When the bullet is of low velocity and small size, so that there is no extensive direct damage to the brain, the phenomena of concussion are usually altogether absent.

Fractures of this type may be conveniently called localized or limited fractures.

If the external violence is applied over a large area of the skull, as in the case of falls on the head, the inbending of the bone is not so sharp, and therefore considerable deformation is possible before fracture occurs. The site and distribution of such fractures and their extent will depend chiefly on the amount of deformation; and this is determined by the site of the blow and the relative weakness of the various parts of the skull. Fissures tend to originate in the neighbourhood of the place struck, and to spread to distant parts of the skull, avoiding specially strong regions, since these are little liable to deformation. The usual type of fracture following a fall on the vertex will therefore be one or more fissures running towards or into the base through the temporal fossa, where the bone is weaker than that above the external angular and the mastoid processes. In cases of falls on the frontal or occipital regions the fracture may be of longitudinal distribution. It must be remembered that in falls on the vertex the part striking the ground is not the only region in which deforming violence is applied to the skull. The impact of the spine against the occipital condyles tends also to produce deformation and fissuring originating in the base. Such fissures may combine with or remain distinct from fissures originating at the vertex.

Fissures involving the base of the skull are occasionally longitudinal, but, as would be expected, much more often more or less transverse. Such transverse fractures usually cross the middle line, and with a certain amount of obliquity, so that the middle fossa of one side may be fractured and the anterior fossa of the other. There is no great regularity about the distribution of such fractures, and no advantage is to be gained by attempting to enumerate the possible varieties. Fissures of the middle fossa commonly cross the petrous bone and enter the posterior fossa, implicating the middle ear and causing rupture of the tympanic membrane. Again, a fissure of the middle fossa often passes inwards to the region of the pituitary fossa, and thence through or near the optic foramen to the anterior fossa.

The fractures now under consideration are those usually called "fractures of the base of the skull." The name is inadequate and to some extent misleading; a better one would be "fractures from general deformation." They are of practical importance chiefly owing to the fact that they are apt to implicate the base, and therefore to be compound. As they are the result of widespread deforma-

tion of the skull, they are almost always accompanied by well-marked signs of concussion, and by more or less severe and extensive contusion.

LOCALIZED FRACTURES

Numerous descriptive terms have been applied to the various forms of localized fracture. They are self-explanatory, and do not need formal definition; such are, for example, the fractures known as depressed, pond-shaped, gutter-shaped, punctured, and stellate. The term partial is applied to fractures implicating one table only, usually the external. True localized fractures as such are not usually accompanied by much evidence of concussion or other general cerebral disturbance. As already stated, this rule does not always apply in cases of bullet wound. When a localized fracture is accompanied by evidence of serious intracranial damage the latter is due to a complicating injury or hæmorrhage, and not to the immediate effects of the fracture or of depressed bone. Depressed bone, apart from hæmorrhage, is very unlikely to produce any cerebral symptoms, unless it implicates directly some region of highly concentrated function like the motor area, and then the symptoms tend to be isolated ones, such as a monoplegia or aphasia. Coma from the mere pressure of a fragment of bone without hæmorrhage probably does not occur.

Localized fracture in the adult is practically always compound, that is to say, violence sufficiently concentrated to cause a limited fracture at the point struck is almost certain to penetrate the scalp. This is a very important rule in practice, because of the completeness with which some hæmatomas mimic a depression of the bone. The surgeon should always be very suspicious of a supposed depressed fracture if the scalp is intact. The only common exceptions to this rule are the smooth, pond-shaped, depressed fractures of young infants, mostly sustained during birth, and the dislocations at the sutures which occur occasionally in young children where one bone is depressed below the level of the other The least rare form of this injury is perhaps a depression of the parietal bone at the squamous suture Occasionally also a glancing blow from a high-velocity bullet will cause a fracture with splintering of the inner table and severe contusion of the brain without the scalp showing more than a graze. Indeed, it is a good clinical rule that whenever the head has been touched by a high-velocity bullet, however trivial the contact and its immediate consequences may seem to be, a fracture of the skull is highly probable and a contusion of the brain certain.

The chief significance of localized fractures, as they are almost always compound, is their liability to lead to intracranial sepsis In addition, as they are usually depressed and accompanied by

contusion of the brain, they have a liability to be followed frequently by the headache of unresolved contusion and occasionally by epilepsy.

Diagnosis.—This need rarely give rise *to any difficulty if it* be remembered on the negative side that localized fractures rarely occur without a scalp wound, *and on the positive side that all* scalp wounds should be carefully explored with the probe without any *reference to the* presence or absence of symptoms. A scalp wound may be quite small and oblique, and yet lead down to a definite depressed or punctured fracture. If there is the least doubt in the surgeon's mind as to the presence of a localized fracture an anæsthetic must be given, and the wound enlarged so that an adequate exploration can be made.

Treatment.—All localized fractures of the skull must be operated on, with the possible exception of the pond-shaped depressions of infants. In cases of the latter injury, if the depression is deep *and does not show evidence of definite diminution within three or* four days, operation should also be advised. Absence of symptoms *should in no case be regarded as justifying delay in operating.*

The object of the operation is disinfection of the wound, removal of loose and depressed fragments, and in some cases evacuation of blood or liquefied brain substance. The most effective method of disinfection is the systematic excision of the surfaces of the wound in bone and soft parts, so that any potentially infective material is completely removed. If much of the skin has to be sacrificed, covering for the wound can be obtained by sliding over it a flap of adjacent scalp. In general, closure of the wound should be aimed at The prophylactic injection of tetanus antitoxin should never be omitted

If the dura is not punctured or torn it should not be incised *unless there is some positive indication,* such as symptoms or direct evidence of intradural hæmorrhage.

If the dura *is punctured it should be laid open freely* and the underlying brain examined. When the brain is deeply punctured it is desirable to remove *any loose brain substance and any foreign* body which from X-ray or other evidence is known to be present and which can be reached *without unduly prolonged exploration. It is not* advisable to attempt to drain such deeply penetrating tracks.

It is well to carry out these operations under continuous *irrigation* with some antiseptic solution, such as perchloride of mercury 1 : 2,000. Drainage of the superficial wound should usually be employed for twenty-four or forty-eight hours. Moist antiseptic dressings, changed every twelve hours, should be used during the period of drainage.

The pond-shaped depressed fractures of infants may sometimes be raised by inserting an instrument through a trephine opening

at the side of the depression and levering up the affected bone. If this is not effective the depressed area may be cut out with strong scissors and the bone replaced with its convex dural surface outwards This method has the advantage of allowing the dura to be incised freely if there is the least indication of free blood beneath it. The skin incision should be so planned that if the larger operation is found to be necessary an ample flap can be reflected.

Treatment of gunshot wounds of the head does not involve principles different from those already laid down. Operation is of course necessary in every case, the wound of entry, and of exit if such be present, being dealt with for disinfection and for the removal of blood-clot, bone-splinters, disorganized brain matter, and missile fragments. It is important to secure closure of the wound or wounds in order to provide covering for the protrusion of swollen brain which is especially likely to occur.

How far the surgeon is justified in carrying the search for a bullet or shell fragment in a given case is always a difficult problem. Such foreign bodies usually cause no symptoms and may remain latent indefinitely. The infective material they have carried in with them may, however, at any time become active and cause fatal septic complications, even after many years. Again, a secondary operation to remove a foreign body is usually much more difficult than an operation at the time of the injury, for densely indurated brain tissue comes to surround the foreign body and makes the finding and identification of it very uncertain.

FRACTURES OF THE BASE OF THE SKULL

A given fracture of the base is rarely limited to a single one of the three basal fossæ; nevertheless, such fractures are for clinical purposes conveniently classified into those of the anterior, middle, and posterior fossæ respectively.

Concussion, contusion, and compression are, of course, extremely liable to occur in such cases, but will not be referred to further here, as they do not constitute an essential part of the condition. The following description will deal in a summary form with such injuries and symptoms as are essentially due to the fracture itself.

Clinical features.—These may be described under the following heads :—

1. Leakage through the fracture into subcutaneous tissues or mucous cavities. This includes escape of brain substance, cerebro-spinal fluid, or blood
2. Injury of large vessels
3. Injury of nerves.
4. Infective conditions

Fractures of the Anterior Fossa

Causation.—Usually a fissured fracture following deformation; *sometimes a localized* fracture from punctures through the orbit, nose, or mouth; very rarely a fracture of the orbital plate from impact of the brain.

Symptoms. 1. *Leakage.*—Brain substance is occasionally expressed through a fractured cribriform plate into the nose. It is, of course, evidence of very severe violence. *Blood* commonly escapes (*a*) into the nose, and causes external bleeding or is swallowed; (*b*) *into the orbit, causing* staining of the eyelids, subconjunctival hæmorrhage, and proptosis. *Cerebro-spinal fluid* is discharged through the nose occasionally. It is recognizable by its watery character, low specific gravity, and possibly by the ability to reduce Fehling's solution. It escapes in a dropping stream, which is increased by anything that raises the venous pressure—e g. straining and expiratory efforts. Sometimes the escape of cerebro-spinal fluid from the nose becomes *chronic* ("*cerebro-spinal rhinorrhœa*").

2. *Injury to large vessels.*—The ophthalmic vessels are occasionally torn, causing orbital hæmorrhage with marked proptosis. The anterior meningeal arteries, if torn, do not usually give rise to extradural hæmatoma of any size.

3. *Injury to nerves.*—The olfactory nerves are commonly torn by fractures of the cribriform plate. If the patient is conscious, anosmia (possibly unilateral) may be observed. The optic foramen, so called, is rather to be described as a canal, and is fitted closely by the optic nerve and ophthalmic artery, hence the former is especially liable to injury Rupture of the nerve *leads to permanent* blindness of the affected eye and dilatation of the pupil. Illumination of the affected eye will cause no consensual contraction of the opposite pupil, but illumination of the opposite eye will cause contraction of the pupil on the affected side. The oculo-motor nerves are rarely injured, on account of the ample space available for them in the sphenoidal fissure.

4. *Infection.*—Meningitis is the only serious infective complication. In its graver forms it is not common, but there is reason to suppose that minor grades of it occur frequently and are recovered from. It is favoured by pre-existing infective rhinitis, and seems to be encouraged by putrefaction of blood-clot in the nose, and possibly also by too energetic attempts to disinfect the nasal mucous membrane by douching under pressure.

Fractures of the Middle Fossa

Causation.—Usually fissured fracture following deformation, sometimes punctures through the roof of the mouth, and rarely frac-

tures from the condyle of the jaw being driven against the temporal bone.

Symptoms. 1. *Leakage.*—Brain substance occasionally escapes from the external meatus. Blood and cerebro-spinal fluid, especially the former, are much more common. Rupture of the tympanic membrane is, of course, always present in such cases.

2. *Injury to large vessels.*—Rupture of the middle meningeal vessels causing extradural hæmorrhage is not uncommon. Rupture of the internal carotid is rare, and is rapidly fatal unless it occurs, as it usually does, within the cavernous sinus. In the latter case an arterio-venous communication is formed, giving rise on the same side to pulsating exophthalmos and distension and pulsation of the orbital veins. As a rule, vision and the movements of the eyeball are retained. There is a loud, continuous murmur, which is very distressing to the patient, and is often audible at some distance from him

3. *Injuries to nerves.*—The 6th cranial nerve is frequently injured where it lies in contact with the tip of the petrous bone.

The facial and auditory nerves are especially liable to injury in a fracture which passes through the petrous They may be crushed or torn at the time of the fracture, pressed upon by blood within the first two or three days, involved in inflammation within about a week, or, finally, pressed upon by callus during union of the fracture from four to six weeks after the accident. The facial is more commonly affected than the auditory, and the only manifestation which is decidedly frequent is a moderate facial paresis coming on about the second day, and doubtless due to pressure by blood and œdema. Such a condition usually recovers completely.

4 *Infective complications.*—Otitis media is especially apt to follow rupture of the tympanic membrane. A sudden rise of temperature about the third day is very commonly due to this condition. If the otitis is overlooked it is likely to cause spread of inflammation through the fracture, with consequent extradural abscess, meningitis, or possibly cerebral abscess.

Fractures of the Posterior Fossa

Symptoms. 1. *Leakage.*—When the basilar process is fractured, blood and cerebro-spinal fluid may escape into the pharynx.

2. *Injury of vessels.*—Rupture of the basilar or vertebral artery is rare, because the relation of these vessels to the bone is not close. It is almost necessarily a rapidly fatal accident.

3. *Injuries to nerves*—The facial and auditory nerves have been referred to already. Of the other nerves in the posterior fossa the glosso-pharyngeal, vagus, and spinal accessory are but very rarely

injured. The hypoglossal is occasionally damaged, with the production of paralysis and atrophy of half the tongue.

4. *Infective complications* can arise only when the basilar process is fractured or when there is a localized compound fracture in the suboccipital region. The latter is very uncommon as a source of infection, because the bone is so thickly covered by muscles, and because direct fractures of the posterior fossa are for the most part rapidly fatal from injury to the medulla.

Diagnosis of basal fractures.—Certain features of basal fractures call for special mention in relation to diagnosis:

Bleeding into pharynx.—(*a*) The blood may be swallowed without any escape externally. Vomiting of altered blood at a later period may lead to a suspicion of abdominal injury. The pharynx should always be inspected with a good light to establish directly whether hæmorrhage is occurring there. (*b*) The blood may accumulate in the pharynx if the patient is lying on his back. During respiration air is forced through this blood and aerates it. When the pool of blood fills up enough to touch the upper opening of the larynx, the patient coughs and brings up a large amount of bright-red frothy blood The resemblance to a case of injury of the lung then becomes very close.

Bleeding from the nose or external meatus.—The actual source of the blood should always be ascertained by direct examination through a speculum. Laceration of the external soft parts very readily occurs in both ear and nose In the case of the ear, when chronic otitis media is present the jarring of a fall may cause granulations to start bleeding. Fracture of the base cannot be regarded as the source of hæmorrhage from the meatus unless the rupture of the membrane is actually seen. It usually appears as a thin, red, slightly jagged, and more or less vertical streak crossing the membrane. Blood may be seen coming through it.

Orbital hæmorrhage.—The "black eye" produced by bleeding into the orbit has certain characters which distinguish it from the black eye due to direct external violence, such as a blow of a fist. In the former the blood is checked in its anterior extension by the palpebral fascia so that the discoloration of the skin is limited by the orbital margin and has the shape of the anterior orbital aperture; moreover, the discoloration, being due to blood which is not immediately subcutaneous, is from the first of a purplish, even brownish, tint, quite unlike the beefy redness of a recent black eye of the ordinary type; again, the skin shows no evidence of external violence having been applied to it; and finally, if there is subconjunctival ecchymosis, it spreads forwards from the back of the orbit so that

its posterior limit cannot be seen. On the other hand, in a case of ordinary black eye the staining is not limited by the orbital margin and is of a beefy redness, indicating hæmorrhage into and immediately under the skin; the skin shows superficial excoriation; and if there is subconjunctival ecchymosis it is most marked around the cornea, and does not usually extend backwards so far that its posterior limit cannot be seen.

If orbital hæmorrhage is very severe it may cause marked proptosis and œdema of the conjunctiva, and give rise to a suspicion of arterio-venous aneurysm or thrombosis in the cavernous sinus.

Treatment of fractured base.—Apart from complicating injuries of the brain and intracranial hæmorrhage, treatment is chiefly concerned with the prevention and control of infection.

When there is bleeding from the nose the patient should be propped up in bed to a moderate degree to check oozing, and efforts should be made to keep the nose clear of any great accumulation of clots A passage can generally be kept open through the inferior meatus by mopping, and very gentle douching may be used through this. No attempt should be made to clear the upper and relatively aseptic part of the nose by energetic syringeing. If the patient is conscious he should be forbidden to blow his nose, on account of the possibility of septic matter being driven through the cribriform plate. The nostrils should never be plugged.

In hæmorrhage from the ear the meatus may be swabbed out *with antiseptic mops, but on no account syringed.* The pinna and neighbourhood should then be disinfected and a large dressing applied. Propping the patient up in bed discourages not only the oozing of blood but also the discharge of cerebro-spinal fluid.

In fractures through the tympanum a careful watch for the onset of otitis media should be kept. If the temperature rises the membrane should be examined and, if its aspect causes any suspicion of distension, freely incised. If, in spite of a free incision, the temperature remains raised and the patient complains of headache or shows any other sign of intracranial infection, the skull should be opened immediately above the ear and the region of the tegmen tympani explored and drained.

Any suspicion of meningeal symptoms should lead to a lumbar puncture being made and all contents of the fluid being examined. A definite polymorphonuclear leucocytosis indicates a beginning meningeal infection. Frequently lumbar puncture once or twice repeated leads to the rapid subsidence of such a condition. Should, however, the meningeal symptoms progress, the region of the skull from which the infection may be supposed to come should be opened up, the dura incised, and the focus of infection drained

DISEASES OF THE SKULL

ACUTE INFECTIVE CONDITIONS

Suppurative Periostitis

This condition occurs only as the result of an infected scalp wound or of a suppurating cephalhæmatoma. In either case it is apt to be accompanied by slight superficial necrosis of the skull If drainage is established early there is often no necrosis, while if drainage is much delayed a penetrating infection of the bone is apt to occur, possibly with intracranial complications. After drainage has been properly established the occurrence of necrosis is recognized by an area of bone remaining uncovered by granulations and of a dead-white colour. As a rule, it is not desirable to attempt to remove the sequestrum until it is loose. The sequestrum does not usually comprise more than a thin scale of the outer table.

Acute Osteo-Myelitis

This occurs in three forms: (*a*) "Acute necrosis," that is to say, an acute staphylococcal inflammation, usually secondary to some distant skin lesion, and occurring almost exclusively in children. The condition is decidedly rare, usually affects the frontal bone, and is of great gravity. (*b*) As a complication of infected scalp wounds, especially with penetration of the pericranium. The infection spreads into the diploe along the veins. The scalp wound may be quite small and often heals readily, even while the bone lesion is developing. The region of the wound becomes painful, tender, and œdematous; headache, giddiness, and fever appear. Exposure of the bone shows it to be avascular and of a yellowish colour (*c*) As a complication of infection of the frontal sinus or mastoid antrum. It is especially liable to follow operations for frontal-sinus empyema, and seems to be favoured by methods in which, after free opening up of the bony tissues, adequate drainage is not provided. It is apt to run a subacute or chronic course, spreading from the original focus widely throughout the vault of the skull, and tending inveterately to relapse after apparently radical operations. It is a very fatal complication, and very resistant to treatment. The fatal termination is brought about by meningitis or sinus thrombosis.

Treatment.—All forms of osteo-myelitis of the skull demand very energetic treatment. The seat of the disease must be freely exposed, and all bone showing the typical yellowish, bloodless appearance should be freely cut away. It is rarely enough to remove the outer table alone, and the whole thickness should at any rate be removed at some part so that the possibility of extradural abscess may be excluded. The spreading osteomyelitis of frontal-sinus disease must be attacked especially early and energetically.

Typhoidal Bone Infections

The cranium is one of the less common sites of bone infection in typhoid fever. The condition has all the ordinary characters of such lesions. It arises during the subsidence of the fever or, more frequently, during convalescence. It takes the form of a subacute or chronic osteo-myelitis with a fair amount of surrounding sclerosis. The tendency to suppuration is slight and the lesion may remain stationary with occasional exacerbations for years. A painful tender lump forms on the skull; it is of low elevation and has

shelving borders; even in the absence of suppuration the centre of the swell- [illegible] tissue; the peripheral [illegible] of typhoid fever, many [illegible] eaction at considerable dilutions. In the more chronic forms there is no great need for treatment unless the symptoms are troublesome. If operation is undertaken the affected bone should be freely removed, as relapses are liable to occur after more conservative procedures.

TUBERCULOSIS

This is a comparatively uncommon condition, and occurs in the form of a chronic osteo-myelitis which sooner or later leads to slowly developing tuberculous abscesses on one or both surfaces of the skull. It affects children and young adults, and generally runs a symptomless course until abscess-formation occurs. The usual pulpy swelling then forms under the skin and ultimately liquefies; the skin becomes thinned and discoloured. If treatment is delayed the abscess bursts and secondary infection greatly increases the gravity of the case. The bone lesion is usually single, and may be very extensive, but multiple abscesses apparently distinct may appear over it. If the disease progresses unchecked, meningeal infection is apt to occur, as the result of the spread of secondary pyogenetic infections rather than of tuberculosis. In diagnosis the only condition that is at all likely to be mistaken for tuberculosis of the skull is secondary malignant disease. In the former the external swelling is low, flattened, and lax; at operation the amount of actual direct perforation of the skull is slight, and the characteristic caries of tuberculosis is found surrounding the focus of disease. There is never any noticeable new formation of bone or sclerosis. Early and energetic operative treatment is necessary to avoid any risk of rupture of the abscess and secondary infection. The diseased part must be exposed by a large flap and freely removed, the whole thickness of the bone being taken away. The wound is closed without drainage.

SYPHILITIC DISEASE OF THE SKULL

Gummatous osteitis of the skull, though apparently much less common than it was, is still a condition of great importance in diagnosis

The beginning of the local lesion is sometimes apparently due to injury. A given region of the skull, perhaps especially the frontal part, becomes the seat of a diffuse gummatous infiltration accompanied by a considerable sclerosis and thickening of the affected bone and surrounding parts. If the bone is exposed at this stage it will be found thickened, dense, and of a yellowish, avascular appearance. The infiltrated bone is marked off from the surrounding sclerosed but otherwise healthy bone by a thin and sinuous red line, which is in fact a shallow groove occupied by granulation tissue. This formation of granulation tissue is the beginning of the process of separation of the diseased bone. The progress of this separation is extremely slow on account of the antecedent sclerosis, and it is doubtful whether it would ever become complete in the absence of secondary pyogenetic infections The very extensive bone destruction sometimes seen is no doubt always due to necrosis having been intensified and hastened by such infections.

Syphilitic osteitis is not commonly accompanied by manifest intracranial syphilis. It is a painful disease, often causing severe and sometimes agonizing pain. This pain usually takes the form of headache, but

sometimes resembles trigeminal neuralgia in being paroxysmal and affecting certain branches of the 5th nerve. A very small focus of the disease may cause very severe pain. *In such cases it may be necessary to shave the head before a diagnosis can be made.* The diagnosis is in general not difficult. The diffuse irregular thickening produced by an endothelioma *infiltrating the skull* is sometimes mistaken for syphilis. In the former there are usually cerebral symptoms; the lesion tends to form a considerable projection, and does not involve the skin until the swelling is of a fairly large size. A skiagram should invariably be taken, as in all cases of disease of the skull.

Treatment.—Gummatous osteitis is sometimes resistant to antisyphilitic remedies. When such treatment has failed there should be no hesitation in advising operation, for involvement of the skin must be avoided at all *costs lest a pyogenetic infection be added. A large flap* should be reflected and the diseased bone cut away.

TUMOURS OF THE SKULL

Sarcoma

Sarcoma occurs as a central or as a periosteal tumour.

(*a*) *Central sarcoma.*—True myeloid tumours of characteristic structure *are very rare in the vault of the skull. In the single case which has come* under my notice the tumour arose in the frontal bone and had the typical globular form. Central tumours of other than myeloid structure are not so rare. They are much more *definitely* malignant, and cause a *more* diffuse expansion of the bone than does a myeloid. They may, however, remain encapsuled by a distinct layer of bone for a considerable time.

(*b*) *Periosteal sarcoma* is the commonest primary tumour of the skull. It is of rapid growth and great malignancy. On whichever aspect arising, it tends very soon to destroy the bone and spread on the opposite surface. Evidences of [illegible]
but the abse[illegible]
cranial extent of the tumour. For this purpose, and [illegible]
extent of destruction of the bone, radiography is indispensable. In the early and operable stages of the tumour the disease is apt to be mistaken for some relatively trivial condition, such as a sebaceous cyst, a dermoid, or a tuberculous abscess.

Treatment.—In an early case an attempt should be made to remove the tumour. *Very free exposure* by the reflection of a large flap is necessary. Division of the bone should be begun at a distance from the tumour lest uncontrollable hæmorrhage be produced. If the skin is involved by *the tumour a flap cut from adjacent parts* must be used to fill the defect produced by the excision. In inoperable cases treatment by radium implanted into the growth should be used.

Secondary tumours of the skull are of great clinical importance, and frequently lead to mistakes in diagnosis. A single metastatic growth *in the skull is not very rare in carcinoma of* the thyroid or in hypernephroma of the kidney. It is a valuable clinical rule that a diagnosis of primary malignant *disease* of the skull should never be made until the presence of malignant *disease* elsewhere has been excluded. Examination should be directed especially to the thyroid, kidney, breast, and prostate.

A peculiar clinical picture is sometimes produced by multiple cranial

metastases in cases of sarcoma of the kidney in children. Numerous rounded soft nodules appear over the cranium and are likely to be mistaken for foci of tubercle. In the later stages bilateral exophthalmos is apt to appear as the result of growths in the base of the skull. The primary renal growth is often symptomless for a long time, so that the true nature of the case may escape diagnosis.

It may be noted here that bilateral exophthalmos is also a usual manifestation of the rare condition known as chloroma.

Osteoma (*see* under Tumours, Vol. I., p. 420)

CONDITIONS ASSOCIATED WITH DEFECTS IN THE SKULL

CONGENITAL DEFECTS

Meningocele and Encephalocele

Congenital protrusions of the intracranial contents through openings in the skull are fairly common, though less so than spina bifida. Such conditions are most commonly found in the middle line and in the occipital region, the gap in the skull being in the lower part of the occipital bone. In all other situations they are comparatively rare. They are occasionally found at the root of the nose in the middle line, and on the lateral aspect of the skull in the mastoid region.

Meningoceles issuing from the skull through the base are very uncommon, but of some importance on account of serious mistakes in diagnosis to which they may give rise. Basal meningoceles occasionally are found in the orbit, but usually they are median. Two forms occur: an anterior, associated with a cleft in the cribriform plate and occupying the nose, where it may readily be mistaken for a polypus; a posterior, escaping through the sphenoid bone and projecting into the naso-pharynx and mouth. The former has been supposed to be associated in its origin with the foramen cæcum, the latter with the cranio-pharyngeal canal.

The sac may contain meninges and cerebro-spinal fluid only (meningocele), or brain substance in addition to these (encephalocele). The brain substance of an encephalocele may contain a diverticulum of the ventricle or be a mere conglomerate mass of nervous tissue. Protrusions into the orbit are said usually to be encephaloceles.

Meningoceles and encephaloceles may be of great size at birth and be associated with other malformations. In such cases they are of little importance, as treatment is usually impossible. Pedunculated occipital meningoceles, when of moderate size, are readily curable by excision with suture of the opening in the meninges. Generally speaking, encephaloceles should not be interfered with by way of operation.

Basal meningoceles of the posterior type are rarities, and, on account of the liability to infection from the mouth, seem to be rapidly fatal. In the case of a pure meningocele, excision should be attempted soon after birth. The anterior type has been mistaken for a polypus and removed with a snare. At least one such case was immediately operated on, and the opening in the meninges successfully sutured.

Dermoids of the Skull

These are not at all uncommon. They occur in or near the middle line of the cranial vault or at the fronto-malar junction. They are usually of

an opening; more usually there is tenderness about the scar and an unpleasant consciousness of the movements that accompany changes in intracranial tension such as are produced by alterations in posture, by straining, laughing, coughing, or making any physical effort. A considerable number of patients complain not only of the unpleasant sense of movement in the scar at these times but also of giddiness, vague discomfort or even pain. There is a class of case, moreover, in which definite headache occurs. This

is lying down, or only soon after he has risen in the morning, some causal relation with the opening may be suspected. In such circumstances closure of the opening will probably be of value as regards the epilepsy.

It is probable that most openings in the skull that result from injury or operation should be closed. When the opening is of considerable size, and the scar in it is freely movable, when the intracranial tension is normal, and when there are definite symptoms of the type above described, there can be no doubt that an operation should be done. A method of rigid

HERNIA CEREBR'

When the intracranial tension is normal there is no tendency for the brain to protrude through an opening in the skull, but rather, as already pointed out, a slow sinking-in of the overlying soft parts occurs. A hernia cerebri is therefore invariably an indication of abnormal intracranial tension. The formation of the hernia is thus beneficial in that it affords more or less relief of the increased tension, diminishes the severity of the pressure symptoms, or even abolishes them altogether. It is clear, therefore, that any attempt to control the formation of the hernia as such—as, for example, by external pressure—must be useless and harmful. Treatment, to be effectual, must be directed to the increased intracranial tension.

Two varieties of hernia cerebri may be distinguished, the closed and the open

In the *closed* variety the soft parts are intact over the protrusion, which is the result of a decompressive or exploratory operation. If the cause of the increased intracranial pressure is temporary (œdema, chronic meningitis, etc.) the hernia will subside. If the cause is progressive the hernia will gradually increase, it may be indefinitely, or more probably to a certain size, when it is checked by the formation over it of a dense dural membrane, or by wedging of the brain in the opening in the skull. In such an event symptoms of pressure which have been relieved by the formation of the hernia are likely to reappear. In some longstanding cases the bulk

of the swelling comes to consist of cerebro-spinal fluid, and then the protrusion may be temporarily or even permanently reduced by one or more tappings.

In the *open* variety of hernia cerebri the soft parts are deficient over a greater or less extent of the swelling, and the brain is exposed. This condition occurs (1) in connexion with septic compound fractures associated with injury of the dura and infection of the brain, and also after operations for the drainage of cerebral abscesses; (2) as a complication of aseptic decompression operations in which the suture line has yielded to the pressure of the protruding brain; (3) as a late sequel of decompression operations in which a cerebral tumour protruding through the skull has destroyed the integuments by pressure.

Treatment.—In the *first* of the open forms no direct treatment is necessary, as a rule. If the septic process is spreading uncontrollably, the outlook is very bad; if, on the other hand, the infection is localized and properly drained, the hernia will gradually disappear as the infection subsides. If the hernia seems to be interfering with drainage, it may be cut away; and if cerebral symptoms are persisting, the opening in the skull should be enlarged.

In the *second* form prompt treatment is necessary. Hernia-formation can always be prevented if a large enough skin-flap is made at the primary operation. Sometimes, however, it happens that the bone opening has to be extended in an unexpected direction, and this may bring the suture line near to or within the margin of the opening. In such cases the brain is very likely to insinuate itself between the skin edges and become exposed. This is always a serious but by no means a necessarily incurable complication. Fortunately, it does not usually occur in more than a small part of the wound. As soon as it is recognized the wound should be opened up at the part affected, the protruding knuckle of brain removed, and the skin closely sutured. Sound union is the rule in such cases if the protrusion is not very large and asepsis has been maintained. If the first attempt at suture fails, there should be no hesitation in repeating it. In cases where the surgeon has been compelled to bring the bone opening near to the skin suture, particular care should be taken to dress the wound at least every other day, to use antiseptics in the dressings in order to maintain the asepsis of the skin, and to remove the stitches a few at a time and not too soon

In the *third* form of open hernia, where the tumour is actually presenting through the skin, radiotherapy is the only resource It should be applied by embedding radium in the substance of the tumour.

INTRACRANIAL INFECTIVE CONDITIONS

The great majority of infective conditions found within the skull reach the intracranial contents by more or less direct extension from neighbouring parts. True pyæmic involvement of the brain or meninges is found less frequently, and is of less practical importance.

The actual pathological conditions met with are conveniently described under the headings of Extradural Abscess, Sinus Phlebitis and Thrombosis, Abscess of the Brain, and Meningitis. It is very common for more than one of these to be found in the same case.

EXTRADURAL ABSCESS

Suppuration between skull and dura is practically always due to infective conditions involving the bone itself. These may be suppurative osteo-myelitis in one of the forms already described, secondary pyogenetic infection complicating tuberculosis or syphilis, or extension from a suppuration in the middle ear or frontal sinus. The dura mater shows considerable resistance to penetration by infective processes, so that an extradural abscess may remain unaccompanied by intradural complications for some time. Ultimately, meningitis or cerebral abscess will develop unless treatment is undertaken. If the abscess be in contact with one of the dural sinuses septic thrombosis is likely to occur sooner or later.

The symptoms of extradural abscess are often confused by those of the condition to which it is secondary, or by those of other intracranial complications. Symptoms which should suggest abscess are fever, localized headache and tenderness, drowsiness, giddiness, and vomiting Optic neuritis may occur. Extradural abscess cannot usually be distinguished from acute osteo-myelitis. Sometimes the abscess runs a latent course and is discovered only during the course of operative exploration. In cases secondary to middle-ear disease the abscess may be subacute or chronic, and may consist of a large mass of granulation tissue with very little pus. These granulomas may destroy the adjacent bone widely and rapidly, and perforate the skull at some distance from the primary focus In such cases, when the amount of pus-formation is very slight a diagnosis of malignant disease is very likely to be made. As a general rule the dura resists the invasion of the granuloma, but sometimes it is destroyed and meningitis results

Treatment.—Extradural abscesses are generally discovered in the course of operations for the conditions they complicate. When they are secondary to middle-ear or frontal-sinus disease, evidence of caries or perforation of the deep wall of the cavity is disclosed to careful inspection, this track is followed up by removing the diseased bone, and the collection of pus is entered Free drainage is essential, and can be ensured only by the removal of a large part of the bone which forms the outer wall of the abscess. In severe cases it may be desirable to remove the whole of the outer wall of the abscess. It is important that the external skin wound be left freely open until it is clear that the suppurative process has ceased to advance.

SINUS PHLEBITIS AND THROMBOSIS

Thrombosis of the dural sinuses is in the great majority of cases due to the direct extension of inflammation from local suppurative lesions. Although in some such cases actual suppuration of the

thrombus does not take place, the process is always essentially an infective one, and due to the invasion of the sinus wall by micro-organisms.

Thrombosis not due to local suppurative lesions does, however, occur in the dural sinuses, but is very much less common. It affects chiefly the superior longitudinal sinus, and is usually a complication of states of marked inanition and toxæmia such as enteric fever and the epidemic diarrhœa of infants. This is of little surgical interest. Non-infective thrombosis of the cavernous sinus is extremely rare. It has been described as a complication of operation for removal of the Gasserian ganglion when the sinus has been wounded and plugging has been used to stop the hæmorrhage.

In the following account infective thrombosis from local causes is alone dealt with.

Pathology.—Thrombosis of a sinus may occur by extension of inflammation through the wall or by extension of clotting along *a tributary or effluent into the lumen of the sinus. In the first case* phlebitis precedes thrombosis by a distinct period; clotting is then likely to occur on the wall for a time before the lumen is closed, and in consequence *symptoms of general toxæmia and of pyæmia will* develop early. On the other hand, extension through a tributary is likely to close the lumen early and to lead to obstruction of the sinus before pronounced pyæmic symptoms appear. It is important to remember that a sinus of which the lumen is still patent may yet be causing definite pyæmia.

When thrombosis has occurred the tendency to suppuration of the clot is very variable. In some cases the clot remains firm and does not suppurate at all; in others suppuration is limited to the region of the primary focus; in others again suppuration is rapid and the clot breaks down almost as soon as formed. In an important but comparatively uncommon group of cases suppuration occurs in distinct isolated foci throughout the clot while organization goes on in the intervals. In this way the lumen of the sinus may come to contain a series of localized abscesses separated from one another by sections in which the sinus has been converted into a fibrous cord. Outlying abscesses of this kind are almost necessarily overlooked at an operation.

Sinus phlebitis and thrombosis, if left untreated, are fatal from septicæmia, pyæmia, or meningitis.

Symptoms.—The symptoms of inflammation of a cerebral sinus may be divided for convenience of description into general effects of the infective process, general evidences of intracranial disturbance, and symptoms special to the individual sinus involved.

General symptoms are usually those of an acute infection. In

certain cases of acute mastoid infection, especially perhaps such as complicate influenza in adults, a sinus phlebitis without complete thrombosis rapidly leads to an acute septicæmia. In ordinary cases, however, the general symptoms are rather those of a pyæmia. Repeated rigors occur, and evidences of septic embolism appear. Always in the early stages, and sometimes throughout the disease, the emboli are arrested in the lungs and do not reach the systemic circulation. The repeated embolism of the lungs produces a characteristic picture. During or immediately after a rigor the patient is taken with a sharp pleuritic pain in the chest, and possibly, if the embolus is large, with some dyspnœa and cyanosis. Cough and pleural friction develop, and in the following twenty-four hours a rusty pneumonic expectoration sets in. The sputum becomes mucopurulent during the next day or two, and, finally, purulent and extremely offensive. The sequence of symptoms is due to the embolus producing a pneumonia which breaks down into a gangrenous abscess. It may be repeated after each embolism, and is particularly likely to occur in cases complicating middle-ear disease.

Occasionally symptoms of pyæmia are absent and the patient shows evidences of a profound toxæmia only—the so-called "typhoid state" In some such cases the presence of diarrhœa, splenic enlargement, and septic rashes may give rise to a suspicion of enteric fever. Rarely the disease is afebrile; if a cerebral or cerebellar abscess develops, fever previously present subsides and the temperature becomes subnormal. Wasting is always present, and is usually rapid and profound.

Cerebral symptoms are very variable Severe headache, giddiness, drowsiness, and vomiting are common Optic neuritis may occur. Irritability, restlessness, delirium, and other evidences of meningitis are common, but usually indicate that complicating meningitis is actually present.

Special symptoms. (*a*) *Superior longitudinal sinus.*—Thrombosis may arise in connexion with an infected scalp wound with or without fracture of the skull, as a complication of tuberculous or syphilitic *skull lesions with secondary pyogenetic infection, or by extension* of thrombosis from the lateral sinus, usually of the right side. Arrest of the blood-flow in the superior longitudinal sinus does not usually interfere with the circulation in the brain enough to cause cerebral symptoms. If the thrombosis extends from the sinus into the veins of the cerebral cortex, symptoms may appear. The patient may then become irritable or delirious, and later drowsy, and there will be paresis of the limbs of the cerebral type affecting the legs chiefly or alone.

(*b*) *Lateral sinus.*—Though occasionally arising from an infected

scalp wound, thrombosis is practically always secondary to middle-ear disease. It may arise by extension of phlebitis through small veins of the ear, but usually appears to be the direct result of an abscess between the sinus and the bone. Such abscesses are due to the extension backwards of mastoid bone disease until the groove for the sigmoid part of the sinus is reached. Phlebitis may begin in the bulb of the jugular vein. Arrest of the circulation does not of itself produce symptoms. If the thrombosis extends into the jugular vein a hard, tender cord will be palpable in the neck, externally to the line of the carotid artery. There are difficulties in observing this physical sign. Generally the swelling is a good deal larger than would be expected, often the size of a man's finger, because the tissues around the vein are also inflamed. Again, the outline is for a similar reason apt to be obscure, and also because of inflamed glands lying over the vein. An erroneous diagnosis may be made through a chain of enlarged glands being mistaken for the vein.

The right internal jugular is normally very considerably larger than the left, and this should be taken into account in the examination of the case

Thrombosis is almost always accompanied by suppuration between the sinus and the bone. Such abscesses penetrate the skull rapidly, and the appearance of one in the subcutaneous tissue over *the line of the sinus* but *away from the mastoid* is almost *diagnostic* of the sinus condition.

(c) *Cavernous sinus.*—The numerous tributaries and effluents of *this sinus render the causes of infection of it very numerous.* Infective lesions in the orbit, nose, face, mouth, and pharynx are all liable to cause septic phlebitis extending to the cavernous sinus. *Facial carbuncle has an especially sinister reputation in this respect,* but conditions apparently trivial, such as alveolar abscess or quinsy, *occasionally lead to the same complication. Cavernous-sinus infection is not very uncommonly secondary to middle-ear disease.* Usually in these cases it is a terminal manifestation of lateral-sinus disease, the thrombosis having spread along the superior petrosal sinus. It may, however, *arise directly from the middle ear by extension* of suppuration into the carotid canal and thence along the artery.

The symptoms of interference with the blood-current are very definite. The eye becomes *prominent, the facial veins engorged,* and the conjunctiva œdematous. This chemosis is often very striking, the swollen conjunctiva forming two large yellow translucent folds which project between the [illegible] *oculo-motor nerves,* being embedded in the sinus, are [illegible] d. The abducens, as would

nerve, not being in direct relation to the sinus, escapes affection, and sight usually persists to a late period until retinal œdema and hæmorrhage cause it to fail. In the majority of cases evidence of involvement of the sinus of the opposite side appears after a few days, and similar signs develop.

Treatment of sinus thrombosis.—The variety of thrombosis by far the most frequent and important is that affecting the *lateral sinus*. The treatment of this will, therefore, be dealt with first.

The diagnosis has usually to be completed at the actual operation. This will ordinarily be the continuation of a radical mastoid operation, and the additional exposure is obtained by an incision directly backwards at the level of the zygoma. Thrombosis of the mastoid vein, perforation of the bone over the sinus, and pus between the sinus and the bone are all strongly suggestive of the presence of sinus infection. The sinus is readily found by continuing backwards the removal of the bone after the exposure of the mastoid antrum. It is usually within ½ in. of the surface and of the posterior wall of the antrum. The normal sinus is recognizable by its blue colour and by its respiratory and arterial pulsations. Sometimes an outlying mastoid cell may for a moment be thought to be the sinus, but any ambiguity is cleared up by the use of the probe and by the removal of more bone. As a rule, pus is found along the sinus. If the sinus does not show any respiratory variations it must be explored. The pus should be wiped away, the surface of the sinus painted with pure carbolic, and two fixation stitches passed into the sinus wall close together at the spot it is proposed to incise The incision is made between the two stitches. If the sinus bleeds freely it may be closed at once by tying the two stitches together. This method of exploration I have found more satisfactory than the use of a needle, which is so often inconclusive and cannot reveal a merely mural thrombosis.

If clot or pus be found the jugular vein must be tied in the neck at once, and bone must be removed along the sinus corresponding with the whole extent of the clot. It may be necessary to follow the sinus down to the jugular bulb. The sinus must be fully laid open. If very firm clot be reached the incision need not be carried through it, but as a general rule it is safest to open the sinus until a healthy part is reached, and then to control the bleeding by plugging between the dura and the bone. For this purpose a piece should be cut from the subcutaneous tissue or muscle of the patient. Gauze should not be used. Bleeding should, if possible, be controlled without plugging into the lumen of the sinus itself. If the exploratory incision shows that the sinus is still patent, but that its wall is thickened by phlebitis and mural clotting, the jugular should be tied in

the neck, and the sinus controlled by extradural plugging and laid open.

The site of ligature of the jugular should be below the lower limit of the clot if such be present. If the contents of the vein are softening, the upper end should be brought to the surface. If there *is no clot in the vein*, or if such clot as is present terminates high up, the ligature should be above the common facial vein. If the clot extends below this the common facial must also be tied. When the clot extends to the root of the neck the case is likely to be a desperate one, but nevertheless the vein should be divided. Even at the risk of including some infected clot, the lower end should be tied to diminish the risk of aspiration of a large mass into the circulation.

It must be admitted that the application in actual practice of the principles of treatment of sinus thrombosis is often a difficult matter. It is frequently hard to determine whether the sinus should be explored, and it is still harder to decide in cases where the lumen is patent whether the sinus is to be treated as infected or not. In such doubtful cases the surgeon may remember that ligature of the jugular is an easy and safe precaution, and that if the sinus has been treated as not infected there must be no delay in exploring again if the symptoms persist unrelieved. Generally speaking, if there have been definite recurrent rigors the sinus should be treated as infected without undue regard for its local appearances.

The *superior longitudinal sinus* must be dealt with on the same lines as the lateral. *If there have been definite recurrent rigors the* right internal jugular should be tied in the neck.

Thrombosis of the *cavernous sinus* is almost uniformly a fatal disease. Numerous attempts have been made to deal with it surgically, and have not been wholly discouraging. If the condition is still unilateral and there is no obviously hopeless complication, such as diffuse meningitis or gangrene of the lung, surgical treatment *should certainly* be undertaken. If the primary lesion is in the orbit the orbital contents should be removed, and drainage of the sinus attempted through the sphenoidal fissure. Otherwise, the temporal route, as for exposure of the Gasserian ganglion, may be considered as an alternative. Seeing that in any case the ocular movements and function are *likely to be much damaged*, it would probably be best to select the less difficult orbital mode of approach.

ABSCESS OF THE BRAIN

A localized suppurative inflammation in the brain substance begins as a focus of acute softening in which the cerebral *tissue* is

at first diffluent and then purulent. Around it is a variable amount of congestion and œdema. The later development of such a lesion varies greatly in different cases. Most commonly a definite abscess cavity forms and enlarges with moderate rapidity, so that in two or three weeks' time it will have produced marked symptoms of cerebral compression. In some cases the established abscess progresses only very slowly, and acquires a thick, dense capsule. An abscess of this type runs a course partially or even wholly latent, possibly for several months. Ultimately, however, severe symptoms are produced, but these are often of such a type that the diagnosis of cerebral tumour is likely to be made. It probably takes at least five or six weeks for a definite capsule to be formed. Such a capsule is often very well defined, and can be drawn out of the brain at an operation with the infliction of surprisingly little damage.

In other cases the lesion develops as a suppurative encephalitis rather than as a definite abscess. An increasingly large region of the brain substance becomes converted into a diffluent material infiltrated with pus. The surrounding parts are markedly œdematous, and the case presents the picture of profound septic intoxication with severe cerebral compression. Frequently in these cases the brain substance becomes actually gangrenous.

Results of extension.—Abscesses of the ordinary acute form may rupture on the surface of the brain or into the lateral ventricle. In either case there is a fulminating increase in the severity of the symptoms, and death ensues rapidly.

Acute suppurative encephalitis may also extend to the ventricle or to the meninges, but usually without any sudden increase in the already very severe symptoms. Chronic encapsuled abscesses, too, may lead to rapid increase of symptoms but generally by the development of œdema or actual encephalitis round them rather than by sudden increase in size.

Very rarely a cerebral abscess partially or even fully discharges itself spontaneously along the track through which the infection has reached the brain. In some such cases a chronic sinus forms which leads into the brain and discharges large quantities of pus for a long time.

Occasionally an infection of the brain substance is quite unlocalized, and an acute diffuse encephalitis develops which is so rapidly fatal from compression that post mortem no suppuration is found.

Varieties of abscess.—Three forms are to be distinguished, according to the mode in which the infection has reached the brain.

1. **Traumatic abscess** results from the direct conveyance of infective material into the brain by a punctured fracture or bullet wound. Foreign material in the form of hair, skin, fragments of

clothing, etc., may be deeply implanted in the brain. The accompanying micro-organisms may at once cause an abscess, or may lie dormant, possibly for years, before undergoing active development.

2. **Abscess secondary to local suppurative lesions.**—This is by far the commonest and most important variety of abscess. Usually it is due to middle-ear disease, occasionally to frontal-sinus disease, and sometimes to suppurating compound fractures or to gummatous or tuberculous lesions in which secondary pyogenetic infection has occurred. The *otitic* form of abscess occurs in the lower part of the temporal lobe immediately overlying the tegmen tympani or in the anterior part of the lateral lobe of the cerebellum. The temporal abscess is at least twice as common as the cerebellar. The route by which infection reaches the temporal lobe is usually marked by a continuous track that can be traced at operation. The roof of the tympanum is carious; a collection of pus or granulation tissue is present between the bone and dura. The dura is softened and possibly perforated where it forms the wall of this extradural abscess. There may be a collection of pus between the dura and brain, the deeper wall of the cavity being formed by an excavation in the latter. Such a collection may produce symptoms of, and fairly be described as a cerebral abscess, though it is more correctly to be regarded as a localized suppurative meningitis. A typical temporal abscess, however, lies wholly within the substance of the brain. The pus is always nearest the inferior surface of the lobe, and usually immediately superficial there. The abscess, therefore, is found most readily when approached from below along the track the infection has followed. When the mode of approach is from the lateral aspect of the lobe through an opening in the skull distinct from that of the mastoid operation an undue amount of brain substance must be traversed, and detection of the abscess is less certain. Otitic abscess in the cerebellum arises in some cases from the spread of infection through the posterior wall of the mastoid antrum by a process similar to that described as causing abscess in the temporal lobe. In such cases extradural abscess and sinus thrombosis are likely to be present. In other cases infection spreads to the labyrinth, and thence along the veins and lymph spaces of the internal auditory canal to the cerebellum.

Cerebellar abscess is sometimes multiple, two or more flattened cavities lying close together, so that when one has been opened the others enlarge and continue the symptoms. When complicated by sinus thrombosis the condition is an extremely serious one. The form due to infection through the labyrinth is therefore relatively favourable.

Cerebellar abscess is less likely to run a chronic or latent course

than cerebral abscess, because lesions in the inferior chamber of the skull produce symptoms much more readily than do lesions in the superior chamber.

3. **Pyæmic abscess.**—Abscesses in the brain arising in the course of an ordinary pyæmia are not common, and are of very little practical importance. The peculiar variety of cerebral abscess which is liable to complicate chronic suppuration in the chest is, however, of considerable interest in that it is usually the sole manifestation of pyæmia. Of the chest conditions which are apt to be complicated by abscess in the brain, bronchiectasis and empyema are by far the most important, especially the former, in which disease this complication is a common cause of death. Nothing is known in explanation of the remarkable liability of intrathoracic suppuration to cause cerebral abscess. It may develop at any time in the course of bronchiectasis, but in chronic empyema seems perhaps especially liable to follow operative interference. It is practically unknown in pulmonary tuberculosis. The abscess is single in about half the cases. Two or three or even more abscesses may be present. The cerebellum is but rarely affected. As a rule, the abscess runs a fairly rapid course, and is fatal in two or three weeks after the first appearance of symptoms

Symptoms.—Abscess of the brain may produce (1) general symptoms of a suppurative lesion, (2) symptoms of a special grade of increased intracranial tension, and (3) focal symptoms due to implication of immediately adjacent structures.

General symptoms of suppuration.—An initial rigor with high fever is common. More than one rigor may occur, without necessarily indicating a sinus-phlebitis complication. Persistent high fever is sometimes seen, especially in acute encephalitis without localized abscess, but in most cases the temperature falls to or below normal within the first few days Some cases are afebrile throughout, especially when the abscess is of pyæmic origin, and therefore unlikely to produce much reaction.

A fairly intense leucocytosis is usually present.

Of other manifestations of a septic process, rapid and profound wasting is common, and often of some diagnostic value.

Symptoms of increased intracranial tension.—Three main types can be distinguished according to the way in which the intracranial tension is affected, and they may be described as the acute, the subacute, and the chronic forms In the acute form there is a rapid and extensive affection of the brain, with much œdema, and the symptoms are those of an acute meningitis; in the chronic form the abscess, usually encapsuled, tends to increase slowly without much surrounding œdema, and the symptoms resemble those of

cerebral tumour; the subacute form, which is the commonest and the classical type, is a progressive lesion advancing with moderate rapidity and accompanied by a considerable amount of œdema, which produces widespread effects of moderate intensity. The clinical manifestations of this form constitute a fairly stable picture which may be regarded as of considerable diagnostic value. In this picture the classical features are mental changes, slow pulse, and subnormal temperature. The pulse-rate may fall as low as 40 to the minute. A rate between 50 and 60 is common. There is not often an equal reduction in the respiration rate. A reduction of the temperature to 97° F. or below is common. The temperature, however, may be normal. Marked oscillations below the normal line are sometimes seen. *The mental changes are the most suggestive and* well defined. The patient is dull, somnolent, and without initiative; when asked questions he responds slowly, and as if thinking were an effort, but *without showing any true confusion. If a question* is put the answering of which involves much thought it may fail to elicit a response, or the patient, after an effort to answer, gives it up. If much plied with questions he may become irritable, but more usually he ignores the cross-examination. When the mental change is marked and it is difficult to get responses at all, it will be found that a request made in a quiet, matter-of-course way is much more likely to be responded to than if the patient's attention is actively stimulated and the request, as it were, fired at him point-blank. The typical development of these mental symptoms is much more likely to occur with abscesses above the tentorium than with abscesses below.

These symptoms, and especially the so-called "slow cerebration," are sometimes regarded as peculiar to cerebral abscess. They are, however, merely the outcome of the slight diffuse interference with the cerebral circulation that is due to the pressure of the abscess, and especially *of the œdema surrounding it. The intensity of the* pressure, and the rate at which it develops, are the factors which determine the production of the clinical picture. Other conditions in which the same factors are at work produce the same symptoms as are, for example, seen with certain cerebral tumours during an attack of œdema, or with extensive chronic subdural hæmorrhages. The conception that "slow cerebration" is in any way characteristic of cerebral abscess is likely, therefore, to lead to serious errors in diagnosis. In advanced cases profound coma ultimately supervenes. Other symptoms which are to be regarded as evidence of a more or less diffuse increase of intracranial tension are headache, vomiting, giddiness, and optic neuritis. Headache is usually very severe and persistent. Evidence of the persistence of the head-

ache is in most cases to be made out even when consciousness is deeply affected. The *severity of the headache* is of considerable value in diagnosis.

Vomiting almost always occurs at the onset and usually continues throughout; when persistent it shows no relation to the presence of food in the stomach. In some cases vomiting is due to a direct involvement of the medulla, and is then to be regarded as a focal symptom. When marked and persistent, therefore, it should always suggest that the abscess is cerebellar. Optic neuritis is not very common, especially in the acute and subacute cases, and is not of much diagnostic value as regards abscess. It occurs in all the intracranial complications of middle-ear disease, and even in acute otitis media when no other intracranial signs are present. When present in cases of abscess it tends to begin on the side of the lesion.

Focal symptoms.—These direct evidences of implication of structures in the immediate neighbourhood of the abscess constitute by far the most important group of symptoms. They are by no means always obvious, and the observation of them demands a thorough familiarity with the signs of nervous disease and a systematic examination of the patient.

A full discussion of the various groupings of focal symptoms which may occur in abscess of the brain is not possible here. The symptoms of the two forms of abscess which are incomparably commoner than any other, viz. temporal and cerebellar abscess, will alone be dealt with.

Focal symptoms of abscess in the temporal lobe (temporo-sphenoidal abscess).—The lesion is in the substance of the temporal lobe about the middle of its antero-posterior extent and near the inferior surface. The surrounding parts by pressure on which symptoms may be produced are as follows: Above and somewhat externally, the first temporal gyrus; directly above, but separated by the Sylvian fissure, the motor cortex, that part concerned with the face being nearest, while the leg area is the most remote. Internally and above is the internal capsule passing down into the crus cerebri. The fibres in the internal capsule are so arranged that those for the leg are nearest the abscess and those for the face most distant. Internally and below is the midbrain with the oculo-motor nucleus. Anteriorly in the front end of the temporal lobe are the parts concerned with the special senses of taste and smell

Dilatation and paralysis of the pupil from pressure transmitted to the midbrain are common. Weakness of some of the ocular muscles may also occur; ptosis is perhaps the commonest of such symptoms, but the other muscles supplied by the 3rd nerve may be affected. Weakness of the *external* rectus may be mentioned in

this connexion. It is not uncommon in all intracranial complications of otitis media, and even occurs in otitis media without other obvious intracranial affection. It is probably due to implication of the trunk of the 6th nerve either by means of a meningitis or by direct extension of inflammation to the nerve where it crosses the tip of the petrous bone. It is of little or no value in the diagnosis of *temporal* abscess.

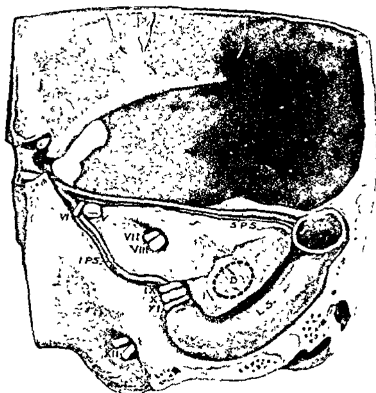


Fig. 737.—*Anterior wall of cerebellar fossa, to show grouping of cranial nerves.*

The dotted outline, marked D, shows the region in front of the lateral sinus through which a cerebellar abscess may be drained This route has the disadvantage of not permitting immediate decompression if the abscess cannot be found or the infection is diffuse

Hemiplegia, hemiparesis, or monoplegia is a fairly common symptom. It is usually due to pressure on the pyramidal tract, and therefore is most marked in the leg. When due to pressure on the cortex it is likely to be most marked in the face, it may be accompanied or preceded by *Jacksonian fits*, and if the lesion is on the left side it may be associated with *aphasia*.

Pressure on the first temporal convolution, if the lesion is on the left side, will cause word-deafness, which is then a very valuable localizing sign. Lesions affecting the right first temporal convolu-

tion are not likely to produce symptoms of value. Auditory hallucinations and deafness in the opposite ear have been described. The former, should they occur, are more likely to be of localizing value than the latter. Local disease of the ear must, of course, be excluded.

More distant effects of the abscess are occasionally to be observed, such as hemianæsthesia or even hemianopia from backward pressure, or hallucinations of smell and taste and possibly anosmia on the same side from forward pressure.

Focal symptoms of cerebellar abscess.—These are more constantly present than focal symptoms of temporal abscess, because the space below the tentorium is small and the pressure of the abscess very readily reaches important structures.

The structures in the posterior fossa which may be implicated by a cerebellar abscess are (1) the cranial nerves, (2) the pons, and (3) the cerebellum itself.

The six *cranial nerves* which traverse the posterior fossa are distributed in three groups, an anterior (5th, 6th), a middle (7th, 8th), and a posterior (9th, 10th, 11th, 12th). Of the anterior group the 6th is commonly affected, but, for reasons already given, the consequent weakness of the external rectus is of little value. Of the middle group both nerves are apt to be involved. Both, however, are so often affected by otitic disease that the consequent deafness and facial paralysis are of no diagnostic value. The 5th nerve and those of the posterior group are very unlikely to be involved. (Fig. 737.)

Pressure on the pons may cause a paresis with exaggeration of reflexes in the limbs of the opposite side. Such a paresis is not common, but the possibility of its occurrence must be remembered in order to avoid an erroneous diagnosis of temporal abscess.

The true *cerebellar signs* are by far the most valuable; careful and repeated examination will almost invariably reveal such of them as will render a definite diagnosis possible. (*See* Chart 8.) The most important are as follows:—

1. *Ocular signs.*
   - Nystagmus.
   - Weakness of conjugate movements.
   - Skew deviation.
2. *Signs affecting the limbs.*
   - Inco-ordination of movement.
   - Paresis of limbs.
   - Hypotonus of muscles.

The *nystagmus* is brought out by lateral rather than vertical movements It is especially marked when the eyes are directed to the side of the lesion, and it tends to increase with the progress of the disease The characteristic movement is a slow jerk of the

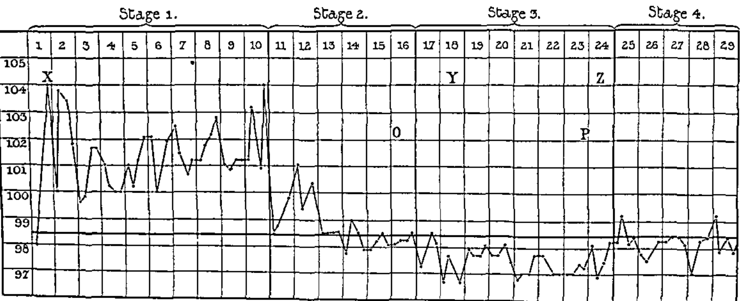


Chart 8.—Temperature chart of a typical case of cerebellar abscess, showing gradual evolution of symptoms. Patient admitted with acute mastoid disease; radical mastoid operation done at once.

Stage 1 No relief of symptoms, average minimum pulse rate 70

Stage 2 Fall of temperature without relief of symptoms; average minimum pulse-rate 62, giddiness, drowsiness.

Stage 3 Subnormal temperature; nystagmus, skew deviation, and weakness of conjugate movements; average minimum pulse-rate 57 5. After six days of subnormal temperature and ocular signs cerebellar paresis appeared

Stage 4. After drainage of abscess. Rapid disappearance of symptoms. Average minimum pulse rate 83 5; temperature rose to normal.

At O, ocular symptoms appeared; at P, cerebellar paresis; at X, mastoid operation; at Y, exploration of cerebellum, abscess not found; at Z, abscess found and opened.

eyes towards the side of the lesion, followed by a slow swing back to the middle line. When the eyes are directed to the side opposite the lesion the movements are finer and more rapid.

Weakness of conjugate movement is seen when the eyes are directed to the side of the lesion. It rarely amounts to an actual deviation to the opposite side.

Skew deviation is usually a transitory and capricious sign, difficult to observe but almost diagnostic. It consists in a deviation of the optic axes often not more than momentary in duration. The one eye—usually that on the side of the lesion—is directed downwards and inwards, the other upwards and outwards.

Inco-ordination of movement may be demonstrable in several ways:

(a) During pointing to a given object.
(b) In the gait.
(c) During rapidly reciprocating movements, such as alternating pronation and supination of the forearm.
(d) During complex habitual movements involving several joints.
(e) By the effects of sudden removal of resistance to movement.

The disturbances are always most marked on the side of the lesion, and usually limited to it; they concern the grosser rather than the finer movements; they are apparent during the actual execution of movement, and therefore, unlike all forms of tremor, do not interfere with the maintenance of a fixed posture, except, of course, when actual paresis is present. The first effect is to deprive complex synergic movements of their normal smoothness and rapidity, so that the action tends to lose its unity and to be resolved into its component factors, each of which is slowly and clumsily carried out. (a) The patient can usually hold his hands out in front of him fairly steadily, but if asked to touch the tip of the nose carries out the movement with characteristic uncertainty. (b) The gait can rarely be observed in cases of cerebellar abscess. If the patient is in a condition to allow of the observation being made, there is the usual staggering gait. The feet are kept far apart, there is difficulty in turning, and the patient tends to fall towards the side of the lesion. (c) The disturbance of alternating movement is best seen in the forearm —dysdiadokokinesis of Babinski. The patient should be made to demonstrate the movement on the sound side first. On the affected side the rotation is slow and jerky, and there is a tendency for the whole arm to be moved. (d) When the lower limb is flexed on the trunk and then rapidly straightened, a cerebellar ataxy may be shown by an inability to carry out the extension of the hip and knee as a single movement, and the patient tends to straighten the knee first and then the hip. (e) If when a normal person is asked to flex

the elbow strongly against resistance the resistance is suddenly removed, there is a short, sharp jerk of further flexion, and then the movement stops. In a limb showing cerebellar ataxy, *when the* resistance is removed, flexion is continued until the hand touches the shoulder.

Hypotonus and paresis.—A cerebellar paresis is on the same side as the lesion, does not involve the face, is not accompanied by rigidity, tends to involve the larger movements rather than the finer, and is not associated with ankle clonus or extensor plantar response. The condition rarely amounts to a complete paralysis; it is extremely characteristic, and is evidence of a large lesion of the cerebellum.

Not only is there no rigidity, but there is also a marked flaccidity of the affected muscles. This hypotonus can be demonstrated by passive flexion of the hip with extended knee or by the possibility of producing slight hyperextension of the knee. Hypotonus and paresis are associated, and one cannot usually be demonstrated without the other.

The reflexes in cerebellar lesions are often affected in such a mixed way as to be almost characteristic in its irregularity. At one examination one deep reflex may be exaggerated and another lost, while at the next examination an exactly opposite condition is found. An intrinsic cerebellar lesion, then, may cause increase or diminution of the reflexes, and the change, whatever it is, is usually transient; when there is marked paresis the reflexes are as a rule lost; plantar extension is never seen unless there is pressure on the pyramidal tract.

The great and constant danger of cerebellar abscess is the liability to respiratory failure through pressure on the centre in the floor of the 4th ventricle. This complication may ensue at any moment during the course of the disease, and is necessarily fatal unless artificial respiration is used and the abscess immediately evacuated.

Diagnosis of abscess of the brain. Clinical types. —Three main varieties occur, the acute, the subacute, and the chronic. The *acute* abscess, which may perhaps better be described as a suppurative encephalitis, tends to produce marked symptoms of an acute septic lesion, with evidences of rapidly increasing intracranial tension. The condition resembles meningitis clinically, but as a rule the temperature is not so high, the pulse-rate is not much quickened and may be slowed, the mental state is usually dull without irritability and delirium. The condition is most frequent in the temporal lobe, is of otitic origin, and is not usually accompanied by localizing signs.

The *subacute* abscess is the common type, and that in which the classical symptoms already given are to be found. It frequently

begins with an acute period of invasion with marked infective symptoms, which are gradually obscured as the disease develops. The *chronic* type is often quite indistinguishable clinically from a cerebral tumour.

Source of infection.—This is always of great importance in diagnosis. Apart from middle-ear disease, the conditions to be thought of are frontal-sinus disease, old compound injuries of the skull, and intrathoracic suppuration. It must be remembered that old injuries may be followed by abscess years after recovery has been apparently complete. Any intracranial symptoms occurring in the course of bronchiectasis or chronic empyema are almost certainly due to cerebral abscess. Abscess arising from frontal-sinus disease or middle-ear disease is almost invariably preceded by some evidence of lighting up of the primary condition. Abscess occasionally occurs as an immediate complication of primary acute otitis or frontal-sinus infection. In old otitis media there will often be evidence of mastoid suppuration, of infection of the labyrinth, or of involvement of the facial nerve. Again, there may be infection of the cervical glands, and finally evidence of sinus phlebitis.

During the course of an exacerbation of an old otitis media the occurrence of certain symptoms should always give rise to a suspicion that intracranial suppuration is occurring. Such symptoms are severe headache, repeated vomiting, a relatively slow pulse coexisting with a high temperature, a rapid fall of temperature to the normal without relief of the headache, and feeling of illness. Sometimes in these early stages, before there is any definite drowsiness or slowness, the patient has a peculiar dazed look which is very suggestive.

The frequency of middle-ear disease as a cause of intracranial suppuration brings with it the risk that any cerebral condition occurring in a patient with middle-ear disease may be mistaken for cerebral abscess While it is true that occasionally an old, apparently quiet otitis gives rise to cerebral abscess without there being any local evidence of an exacerbation of the ear disease, it must be remembered that the great majority of cases of otitic brain abscess show some evidence of local bone disease, such as tenderness or swelling over the mastoid, the recent onset of facial paralysis, or evidence of labyrinthine suppuration. It would be a very serious mistake in a case of cerebral tumour or chronic subdural hæmorrhage to embark upon a preliminary mastoid operation because old otitis media happened also to be present. In cases, therefore, in which there is any doubt as to the relation between the otitis and the cerebral condition, the exploration of the brain should invariably be done as the primary operation.

Diagnosis of temporal abscess.—The situation of the abscess is such that there may be no localizing signs whatever. The local-

izing sign most likely to appear is oculo-motor weakness. Hemiplegia is not likely to be present until the case is far advanced and *evidences of considerable increase of intracranial tension* are present. Hemiplegia without marked drowsiness or coma would be evidence against the lesion being an abscess unless such abscess were a very *chronic encapsuled one.*

As a rule, "slow cerebration" is a pronounced and fairly early symptom of temporal abscess.

Diagnosis of cerebellar abscess.—This can usually be made quite readily after a thorough neurological examination. Generally speaking, mental changes are slight and of late development, whereas *slow pulse and low temperature are early signs.* Some evidence of meningitis in the posterior fossa, such as rigidity of the neck muscles, is frequent.

Of the signs of actual cerebellar disease, nystagmus is the only one which may give rise to doubt, as it may also originate from disease of the labyrinth.

Early and partial disease of the labyrinth causes nystagmus more marked to the affected side; late disease causes nystagmus more marked to the sound side. The grade of the disease can be made out by *the irritability of the labyrinth to the caloric test.* The case in which confusion is most likely to occur is when the nystagmus is most pronounced on the affected side, and may therefore be due to *an incomplete labyrinthine or a cerebellar lesion. If the labyrinth* is shown by the caloric test still to be irritable—that is to say, if the nystagmus is increased by syringeing the ear with hot or cold *water—then the probability* is that the case is one of early labyrinthine nystagmus. On the other hand, if the labyrinth is non-irritable the nystagmus is probably cerebellar.

In actual practice the other signs of cerebellar lesions are usually clear enough to make a diagnosis possible independently of the direction of the nystagmus.

Treatment of abscess of the brain.—Operative treatment is urgently called for in every case. Delay is dangerous, especially in cerebellar abscess, on account of the liability to respiratory failure at any moment.

In cases of chronic encapsuled abscess in an accessible situation it may be possible to remove the wall of the abscess complete with very little damage to the surrounding brain tissue

As a rule, incision and free drainage must be used.

Abscesses of intrathoracic origin should generally be operated on, as they are so commonly single, though on account of the patient's general condition the outlook is always bad.

The treatment of otitic abscess must be considered in some detail.

The natural method of attack is from the ear along the track which the infection has followed, and this should undoubtedly be regarded as the normal route. The radical mastoid operation is done, and such indications of disease of the bone as are found are followed up. In the case of temporal abscess the roof of the tympanum is found to be carious and is removed. Granulation tissue and pus are usually present outside the dura. Often the dura is actually perforated or converted into granulation tissue over the abscess, and a direct passage into the latter is readily made. Enough bone is removed to allow of the dura being freely opened, and a large tube is passed into the abscess. It is often difficult to get the tube fairly placed in the abscess and to retain it in position. If it is at all doubtful whether drainage can be maintained, there should be no hesitation in excising enough of the brain tissue to give an opening into the abscess large enough to ensure drainage even without a tube.

In the case of cerebellar abscess, if the infection has spread through the posterior wall of the antrum the bone is removed backwards until the lateral sinus is exposed. Pus will almost certainly be present in the sigmoid groove, and possibly the sinus itself will be infected. The dura is incised behind the sinus and the cerebellum explored. It is always well to remove the bone freely over the lateral lobe of the cerebellum so that the pressure on the medulla is completely relieved. A further advantage is that if the abscess cannot be found, as is sometimes the case when it is small and deep-seated, the danger of respiratory failure is removed and the abscess, which will enlarge towards the surface, can be readily found and drained at a later date. In cases where the infection has reached the cerebellum by the internal ear—about 50 per cent of all cases, according to some observers—an alternative method is to open the skull immediately in front of the lateral sinus. An opening ½ in. in diameter can be made here without risk of injury to the facial and auditory nerves, which are in front. The route gives very direct access to the majority of cerebellar abscesses, and satisfactory drainage. On the other hand, the opening in the bone cannot be enlarged freely should the extent and virulence of the infection render such a procedure desirable.

A constant danger during exposure of a cerebellar abscess is respiratory failure. Should this occur, artificial respiration must be used, and the abscess exposed and evacuated by the most direct route. There is no need for excessive hurry in doing this, and at all costs any undue violence must be avoided. As long as the failure is purely respiratory there is no great danger if the pressure can be fully relieved. The artificial respiration usually maintains aeration

of the blood quite well, and should not be more energetic than is just adequate to effect this.

The surgeon should on no account allow himself to try to prevent *the occurrence of respiratory failure by doing a lumbar puncture* before the operation. This is likely, by allowing displacement of the cerebellum and medulla downwards into the foramen magnum, to precipitate the very complication it is intended to prevent.

The acute type of abscess, temporal or cerebellar, in which the brain is found to be infiltrated with pus and possibly gangrenous, cannot be dealt with by ordinary drainage. A free opening in the skull *must be made and a large part of the outer wall of the abscess* removed, so that when the brain bulges into the opening the cavity is converted into a flat surface.

The method described above, in which the operation is begun by a clearance of the tympano-antral cavity and the track of infection *is followed into the brain, is not always admissible.* The chief exceptions are cases where there is any doubt as to the cerebral symptoms being due to the middle-ear disease, and cases in which the disease is advanced and the condition of the patient serious. In such circumstances the exploration of the brain is the first step to be taken; an adequate flap must be reflected, the bone freely opened, and the dura incised In exploring the brain a knife is *perhaps the best instrument to use;* the lower part of the temporal lobe and the lateral lobe of the cerebellum may be incised freely without fear of doing damage. When the abscess is deep in the temporal lobe, exploration with the finger may be used with advantage. Puncture with trocar and cannula is quite useless.

INFECTIVE MENINGITIS

Meningitis is probably by far the commonest infective intracranial condition. It may complicate any form of compound fracture of the skull, infective conditions of the bones such as osteomyelitis or necrosis, or *infective foci in and about the skull such as* frontal-sinus disease or otitis media; finally, it is a common terminal complication of all other infective intracranial conditions. In middle-ear disease it begins more commonly in the posterior than in the middle fossa. It complicates acute otitis fairly often, especially in children.

Serous and purulent varieties are described *according to the* nature of the exudate present. No true distinction can be made between these forms, the differences being entirely a matter of the virulence of the infection, and possibly the nature of the microorganism. Doubtless all cases are serous for a greater or less length of time, and it is a well-established *clinical fact that the exudate* after remaining serous for some time may become purulent.

Localized forms, both serous and purulent, occur. No doubt local serous meningitis is a very common occurrence in middle-ear disease, and undergoes spontaneous cure without a diagnosis being made. The frequency of optic neuritis and weakness of the external rectus in the less serious complications of otitis media supports this view. Localized purulent meningitis is scarcely to be distinguished from cerebral abscess.

The **symptoms** of diffuse infective meningitis are very variable, but usually form a fairly characteristic picture in contrast with those of other infective intracranial conditions. Headache, vomiting, high fever, and rapid pulse are common The mental state shows a combination of irritability and drowsiness. There is sometimes violent delirium. General convulsions occasionally occur. Photophobia is constant. Optic neuritis is not very common. The reflexes are exaggerated, and hypertonus of the muscles is present with Kernig's sign. Focal symptoms are often present, and may give rise to some difficulty in diagnosis; such are squint, Jacksonian fits, and monoplegias.

The **diagnosis** is made by examination of the cerebro-spinal fluid, which is under increased pressure and shows the presence of albuminous substances, polymorphonuclear leucocytes, and micro-organisms. Occasionally, owing to obstruction of the foramen magnum by displacement of the brain, the fluid withdrawn by lumbar puncture remains normal.

The **treatment,** if undertaken early and energetically, is by no means so discouraging as was at one time supposed. The essential principle is to attack the source of infection and to deal with it radically. If, as is usually the case, the process originates in the middle ear, a radical mastoid operation must be done with very free removal of every trace of infected bone. At the same time lumbar puncture should be done, but cautiously, not more than 10–20 c.c. of fluid being removed at first. The puncture may be repeated every second day, and the cellular content of the fluid examined. The amount of fluid withdrawn may be cautiously increased. The objection to the free use of lumbar puncture is the tendency it has to lead to displacement of the brain and obstruction of the foramen magnum If the fluid becomes more turbid in spite of these measures and the symptoms increase, the dura should be freely opened in the region of the primary focus and drainage established. The opening in the bone should be large, so that it may not be plugged by the brain and drainage arrested.

THE SURGERY OF CEREBRAL TUMOUR

The term cerebral tumour is used here in a purely clinical sense to denote a local progressive intracranial lesion without the implication that such lesion is a tumour in the strict pathological sense. The

conditions included under the term are therefore of very various origin from the pathological point of view, and have little in common except that their rate of growth is slow in comparison with that of most traumatic and inflammatory lesions.

The *principal varieties* of cerebral tumour are as follows:—

1. **Cysts.**
   - (*a*) Traumatic. — Hæmorrhagic cysts, subdural and *intra*-cerebral.
   - (*b*) Inflammatory. — Localized serous meningitis (localized *arachnoiditis*)
   - (*c*) Parasitic. — Cysticercus; Echinococcus
   - (*d*) (*Neoplastic.*)
2. **Aneurysm** (other than miliary).
3. **Granuloma.**
   - (*a*) Tuberculosis.
   - (*b*) Syphilis.
4. **Chronic abscess** (pyogenetic).
5. **Neoplasm.**
   - (*a*) Of the nerves. — Fibroma. Sarcoma.
   - (*b*) Of the meninges. — Endothelioma (including psammoma and cholesteatoma).
   - (*c*) Of the brain substance. — Glioma. (Sarcoma.)

No systematic account of these conditions need be given here. *Traumatic cysts* have already been considered. *Encysted meningitis* is a rare condition, probably of inflammatory or traumatic origin, in which a localized collection of clear fluid is found between the dura and the brain. It can frequently be made out that the fluid is beneath the arachnoid, and that the cavity is loculated by strands passing between that membrane and the pia. The fluid is often under such tension as to cause considerable pressure on the brain The condition is found chiefly in the inferior chamber but is known to occur also in the superior chamber. It is comparatively common in the spinal theca. Cystic collections of fluid are often found in the neighbourhood of extracerebellar tumours, and may even be mistaken by the inexperienced for the principal lesion. *Cysticercus* of the brain is usually associated with multiple cysticerci in the subcutaneous tissue. Clinically these latter resemble neuro-fibromata, for which they are apt to be mistaken. Gross intracranial *aneurysm* is not common, and rarely produces symptoms until rupture takes place. It is probable, however, that leakage can occur without the production of more than transient symptoms. *Unlike aneurysms elsewhere, intracranial*

aneurysm is extremely thin-walled, apparently because it does not produce reaction in the surrounding tissues and adventitious reinforcement of its walls. Intracranial *syphilis* and *tuberculosis* both occur as a localized tumour or as a diffuse meningeal change, and in both the former variety is likely to be complicated by the latter. Syphilitic meningitis is less likely to become diffuse than is tuberculous meningitis. The latter, however, does in rare cases occur in localized form. Nodular tubercle is decidedly commoner in the posterior fossa than elsewhere, probably by reason of the frequency of tuberculosis of the temporal bone. Operative removal of a tuberculous tumour may precipitate the onset of a tuberculous meningitis.

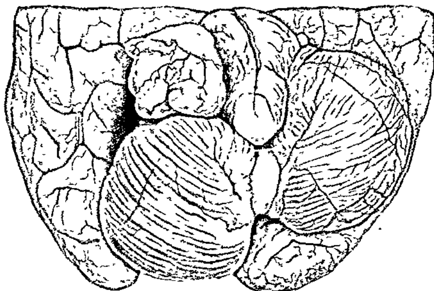


Fig. 738.—Fibroma of right auditory nerve (cerebello-pontile tumour)

A cerebellar decompression had been done on the right side. It can be seen that, although free displacement backwards of the cerebellum has occurred, the decompression has not prevented the tumour from continuing to press on the pons and medulla.

(*This and the following five illustrations are from specimens in the Museum of University College Hospital Medical School*)

Of the true neoplasms *fibroma* is practically limited to the auditory nerve, and is the well-known tumour of the cerebello-pontile angle. (Fig. 738) This is the commonest extracerebellar tumour, and is usually quite benign; occasionally it proves to be sarcomatous, and sometimes it is bilateral.

Endothelioma is always a tumour of the meninges, the velum interpositum, or the choroid plexuses. It is frequently psammomatous. Most commonly it appears to begin in the dura, usually of the anterior, part of the upper chamber, but sometimes in the inferior chamber.

Dural endothelioma spreads on both aspects of the dura. Internally it presses upon the brain, in which it may make a large and deep depression, but without, until the latest stages, becoming fixed to the brain substance. Externally it sometimes destroys the skull by pressure atrophy, but more usually invades the bone, causing a remarkable amount of new-bone formation and leading to an external



Fig. 739.—Thickening of skull from invasion by an endothelioma of the dura mater. Outer aspect of bone.

projection which has an irregular nodular surface, partly soft and partly bony. (Figs 739, 740.)

Cholesteatoma, which is quite distinct from the middle-ear condition described under that name, is a true tumour of a laminated structure with relatively few cells and having a very remarkable glistening pearly aspect. It is probably an endothelioma, and is very rare.

The *glioma* is the true tumour of the brain substance, and possibly the only one. Cushing and his associates have shown that the dif-

ferentiation between glioma and sarcoma may be extremely difficult, and that the more thorough the histological examination the fewer appear to be the cases of true primary sarcoma of *the brain*. *There* are also general grounds, which need not be entered upon here, for supposing that true sarcoma is unlikely to arise in the brain substance. Without pressing the point unduly, it may certainly be said



Fig. 740.—Inner aspect of skull, showing effects of invasion by an endothelioma of the dura.

The new bone due to ossification of the growth is deposited in spicules vertical to the inner table.

that glioma must be regarded as the characteristic brain-substance tumour, and that cases of supposed sarcoma should be accepted with caution.

Glioma is a tumour which shows considerable variations. It may be completely encapsuled and slow-growing, or quite diffuse. An incomplete degree of encapsulation is perhaps the condition met with most commonly at operations. Gliomas are often also the seat of retrogressive changes, of which the most common is liquefaction

and cyst-formation. Sometimes the cyst-formation leads to the solid residue being reduced to an extremely thin layer. There is a good deal of evidence in favour of the view that occasionally gliomas may undergo arrest of growth or possibly complete retrogression after a decompression operation has been done. A striking characteristic of all gliomas is their very slight tendency to invade non-neural tissues, even when they are brought into contact with such by decompression.

Pituitary tumours.—These have been omitted from the foregoing table for the sake of clearness. Two distinct classes of tumour of the hypophysial region are described—those of the gland itself, and those arising in its immediate neighbourhood. Of the gland itself the principal tumour is a form of adenomatous enlargement which is probably of the nature of a hyperplasia rather than a true neoplasm, but which does appear to be capable of becoming the source of a malignant tumour. The swelling may cause enlargement of the sella turcica and extend upwards and press upon the brain. It resembles in many ways the hyperplasias of the thyroid gland; for example, it is liable to undergo colloid and cystic degeneration. While the process is active it is accompanied by evidences of hyperpituitarism (gigantism, acromegaly). The second group of tumours may arise in the stalk of the pituitary body, or in vestigial structures in the neighbourhood of the sella turcica such as the cranio-pharyngeal canal. Such tumours may occasionally be cystic. They tend to press upon the pituitary and to interfere with its functions, causing evidences of hypopituitarism (dystrophia adiposo-sexualis).

Mode of production of symptoms.—A cerebral tumour produces symptoms through the action of several distinct mechanisms.

(*a*) *Direct disintegration and destruction of the actual nervous elements.*—Granulomas and infiltrating neoplasms act to a certain extent in this way, but, unless the tumour arises in a part where function is much concentrated, the symptoms produced by such a mechanism are usually inconspicuous until a late stage is reached.

(*b*) *Pressure of the tumour on surrounding parts, causing circulatory disturbances.*—This is the principal source of symptoms in most forms of tumour. (Fig. 741.) The rate at which the pressure increases being usually slow, the brain substance is able to accommodate itself to a large extent to the slowly progressing circulatory disturbance. This tends to make the symptoms on the whole predominantly paralytic in character, and to obliterate the finer grading of preliminary irritative manifestations seen in some of the acute lesions. Convulsive attacks are the only irritative symptoms at all commonly seen in cerebral tumour, and they indicate a circulatory disturbance of considerable intensity and at the least bordering on anæmia.

Tissues which are rendered anæmic by pressure survive for a considerable time in a condition capable of recovery should the pressure be removed. *How long this period lasts cannot be exactly*



Fig. 741.—Endothelioma of dura invading the longitudinal fissure of the brain and pressing very severely on both frontal lobes.

A decompression has been done on the right side externally to the tumour but just beyond it At the time of the operation the patient was comatose He recovered and lived for eighteen months with no symptoms at all except occasional generalized epileptic fits. In spite of the extreme pressure on both frontal lobes the mental state was practically normal.

stated, but certainly for a considerable time. That many of the symptoms of tumour are due to circulatory disturbance and not

actual destruction is shown by the degree of recovery which is possible after *simple decompression, and the rapidity of such recovery* when the opening in the skull is directly over the tumour.

In the tissues around the tumour œdema tends to appear, and this increases the range through which the effect of the tumour is felt. Such œdema seems to be variable in extent and to be subject to abrupt increases.

With the gradual increase of the tumour and the surrounding œdema a larger and larger extent of the brain is affected, but unless some other mechanism comes into action the condition remains essentially local, the function of the brain beyond the zone of actual disturbance being quite unaffected. It is of cardinal importance to recognize the fact that there is nothing in the nature of a tumour as such to produce a general or even an extensive increase of intracranial tension. Such a condition should be looked upon as a grave complication.

(*c*) *Pressure of the tumour interfering with the circulation of cerebrospinal fluid.*—The situation of the tumour determines the readiness with which this effect is produced, but in their advanced stages almost all tumours tend to have this effect. Tumours of the interpeduncular space tend to obstruct the foramina of Monro and to cause distension of the lateral ventricles; of the quadrigeminal region and crura, to obstruct the aqueduct and cause distension of the 3rd and lateral ventricles; of the cerebellum, to obstruct the foramen of Magendie and cause general internal hydrocephalus. Any such occurrence will cause a marked and bilateral increase of tension and consequent symptoms.

(*d*) *Pressure of the tumour and the secondary increases of tension due to it causing displacements of the brain.*—One cerebral hemisphere may thus become tightly wedged under the falx, the brain stem may obstruct the opening of the tentorium, the cerebellum may be displaced towards the opposite side, and the opposite hemisphere compressed against the skull; finally, and most important, the cerebellum may be pressed down into the foramen magnum and the medulla compressed by it. By this mechanism are produced distant symptoms which have no direct relation to the tumour, and may therefore be most misleading.

Surgical aspects of early diagnosis.—From the foregoing considerations it is clear that there is a marked difference in significance between the true local symptoms of the tumour and the secondary rise of intracranial tension to which it ultimately leads. This increased tension is essentially a late phenomenon, and sometimes even a terminal one. Now, the classical symptoms of cerebral tumour—headache, vomiting, and *optic neuritis—are pressure symp-*

toms, so that if diagnosis is delayed until they appear the disease is necessarily in an advanced stage before the diagnosis is made It is mainly to the lateness of the period at which the disease is usually recognized that the relatively unfavourable results of treatment are due. Hence it is obvious that the standard of diagnosis based on the pressure symptoms must be abandoned, and every attempt made to recognize tumours while they are in the stage of producing local symptoms only. Unfortunately, at the present time clinical methods are not sufficiently delicate to permit of the really early recognition of more than a comparatively small number of tumours. In attempting to attain to the desired standard three considerations should be borne in mind—(1) that any evidence of local cerebral disturbance, however apparently trivial, if persistent and progressive, should be regarded seriously; (2) that minute and *repeated* clinical examination of the nervous system is indispensable in doubtful cases; and (3) that exploratory craniotomy deliberately undertaken as a diagnostic procedure is often preferable to waiting indefinitely for the disease to declare itself in an unmistakable way.

The reasons why early diagnosis is so important in cases of cerebral tumour are sufficiently obvious, but a formal statement of them is desirable, as they are of serious concern to the surgeon. In the first place, if operation is undertaken at a late stage the tumour may have reached a condition in which cure is no longer possible by removal, or in which removal is no longer possible on account of involvement of vital parts, or the dangers of shock or hæmorrhage, or the risk of excessive mutilation. Still more important are the effects of increased intracranial tension. The bulging of the brain as soon as the skull is opened interferes with the proper examination of the lesion, is apt to cause laceration and bruising of the extruded part, and leads to dislocation and damage of the rest of the intracranial contents. All these effects combine to make the operation more difficult, less precise, and much more dangerous than it would be in the absence of increased tension. There can be little doubt that it is to this complication that the majority of deaths *consequent upon the operation are due.* The presence or absence of it makes as much difference to the performance of the operation and its result as does the presence or absence of acute obstruction in dealing with a tumour of the bowel.

The symptomatology of cerebral tumour cannot be dealt with adequately within the limits of this article, and lies rather within the domain of systematic neurology.

Operations for cerebral tumour.—Operations on the central nervous system demand a somewhat special technique. Methods of exploration, of hæmostasis, and of manipulation must be

used which allow for the delicate texture of the brain, the concentration in it of vital function, and the disturbing effects of abnormal *intracranial tension*. *Gentleness* and precision are indispensable throughout; confusion and hurry must be avoided at all costs.

The *incision* in every case should be in the form of a *flap*, and as there must always be some doubt as to the size of opening in the skull which may prove to be necessary, and of the direction in which it may have to be enlarged, the flap should always be large. In the presence of great increase of tension the suture line in the skin cannot be depended on to resist the pressure of the brain, which may force its way to the surface, with all the consequent dangers of an open hernia cerebri. The adhesion of the deep surface of the flap to the margin of skull surrounding the opening is the principal safeguard against this complication, and is to be obtained by the routine use of very large flaps.

Hæmostasis of the scalp wound is best effected by making the incision in short lengths and picking up the vessels as they are divided. No ligatures are necessary, suture of the wound being quite adequate to stop the vessels.

As to the use of *bone-flaps*, no complete rule can be laid down. The practice of individual surgeons varies greatly in this particular. Certain general principles may, however, be defined. A bone-flap should be *used* when there is no evidence of marked intracranial tension, when the opening in the skull is to be in the frontal region, and for operations of purely exploratory character. A bone-flap should *not be used* for operations on the posterior fossa and in cases where there is an advanced degree of intracranial pressure. The making of a bone-flap increases the duration and difficulty of the operation and tends to add to the shock.

In the actual fashioning of the bone-flap many methods may be used. The method of multiple trephine holes connected by saw-cuts is perhaps the simplest. The temporal muscle is available in most cases as a pedicle for the flap.

Decompression operations.—These consist in the making of an opening in the skull and dura to allow of the expansion of the brain (and possibly the escape of cerebro-spinal fluid) into the subcutaneous tissues.

If the opening in the skull be small it is apt to become plugged by the brain and rendered useless. Moreover, the part of the brain plugging the opening at once becomes strangulated, its structure disorganized, and its functions abolished, perhaps permanently. It is not possible to define precisely the size which decompression openings should have, as the needs of the case will vary with the degree and cause of the tension. Generally speaking, an area of opening

containing less than 4 square inches is not likely to be of much value.

The brain, although after the operation in contact with the subcutaneous tissues, never becomes adherent to them in the absence of infection, as a dural layer invariably forms over the hernia.

Certain mechanical consequences of the operation are very important. Three fundamental facts must be borne in mind: (1) The source of the increased pressure is the tumour itself; pressure, therefore, is highest in the neighbourhood of the tumour and diminishes with increasing distance from it. (2) When an opening is made in the skull the underlying brain is forced into it and subjected to a certain degree of strangulation by the margin; this may seriously impair the functions of the herniated part, and even cause disorganization of it. (3) If the opening is distant from the tumour the brain lying between these two regions must undergo dislocation when the hernia forms; there is, in fact, a kind of slow streaming of the semi-solid brain from the focus of high tension (the tumour) to the place of low tension (the opening): large tracts of the brain may thus sustain considerable displacement and deformity, with pronounced disturbance of function.

It follows from these considerations that the local disturbance of the brain at the opening tends to be more marked the nearer the opening is to the tumour, while the diffuse disturbance from dislocation is likely to be more marked the farther the opening is from the tumour. The latter consideration is to be regarded as the more important one. *The ideal situation, therefore, for a decompression opening is directly over the tumour.* (Fig. 742) To give complete relief of pressure the opening should be somewhat larger than the tumour itself, on account of the surrounding œdema of the brain Under such conditions any evidence of added disturbance following the operation is likely to be only temporary. Further reasons for the choice of this situation are that it may cause relief of secondary hydrocephalus, a result which would be very unlikely with a distant opening; that it renders the tumour accessible to radiotherapy; and that the complete relief of pressure may later on render feasible an attempt to remove a tumour which was, at first sight, obviously inoperable.

When the situation of the tumour is unknown the choice of the place for the opening is not so clear. Generally it is best to choose the side of the lesion if this is known. When there is no indication pointing to either side the right-side should be chosen, but it must be remembered that a right-sided decompression for a left-sided lesion may cause serious disturbances from dislocation. For this reason, if the pressure is very severe, bilateral decompression should

be done. In the absence of local indications a "silent" region should be selected for the opening, either postparietal or low in the temporal fossa. The temporal operation is the best, especially for bilateral operations, and may be done with preservation of the temporal muscle (subtemporal decompression). This route has the advantage of allowing some exploration of the base of the brain.

For lesions in the posterior fossa a suboccipital opening is necessary. It should be bilateral and include removal of the posterior margin of the foramen magnum.



Fig. 742.—Vascular glioma of parietal lobe, showing effect of decompression opening placed exactly over the tumour.

The *indications* for decompression are as follows:—

1. The relief of symptoms of inoperable tumours. Headache, vomiting, and optic neuritis can almost always be completely arrested—often for months, sometimes for years. Occasionally decompression seems to arrest the growth of a tumour.

2. For syphilitic meningitis which does not rapidly yield to drug treatment.

3. For increased intracranial tension of unknown origin. In some such cases a definite diagnosis of tumour and a radical opera-

tion may become possible later. It must, however, be remembered that a decompression, by checking the development of symptoms, may prevent the diagnostic localization of a tumour that otherwise might have declared itself and proved capable of radical treatment. This consideration should be a *strong argument against the indiscriminate* and routine resort to merely decompressive operations. In a considerable number of cases in which the cause of the increased tension is unknown, decompression proves to be curative. Most of these are probably inflammatory lesions of a mild grade, some are perhaps renal œdemas, and possibly a few are tumours which undergo retrogressive changes.

4. As a preliminary to the removal of large tumours or tumours producing very severe symptoms.

Radical operations.—The proportion of cases in which a radical cure can be attempted is still small—chiefly, no doubt, on account of *difficulties in diagnosis and delay in initiating treatment.*

Cysts, chronic abscess, gumma, fibroma, endothelioma, and encapsuled glioma can be dealt with with a good prospect of permanent cure as regards the disease. Tuberculous masses may occasionally be removed, but their tendency to be multiple and the dangers of consecutive tuberculous meningitis should enjoin caution in attacking them. Gliomas of an infiltrating type or imperfectly encapsulated are unfavourable as regards cure, and almost always recur. If they were operated on while small and before the coming on of pressure symptoms, so that a free excision could be carried out, no doubt they would prove curable. In dealing with cases of this type it must be remembered that the excision of large tumours from the motor area or its immediate neighbourhood is likely to cause a more or less permanent hemiplegia. Hence, if it is doubtful that freedom from recurrence can be attained, radical operation should not be attempted. (Fig. 743)

No detailed account of operative technique is possible here, as the individual variations of cases are so great. Some tumour operations should be done in two or even three stages. The surgeon should approach most cases with the general intention of doing what is necessary at the one operation. Great judgment is often necessary in deciding whether this intention should be carried out or the procedure divided into stages. Except in cases of chronic abscess, drainage should practically never be used, even after the removal of large tumours.

In **cerebellar operations** the inaccessibility of the seat of operation is the chief difficulty. The patient should be in the prone position with head flexed and the forehead supported on a head-rest. The anæsthetic should be given by an *intratracheal method.* An

always be exposed in the lateral part of the opening. Numerous veins pass between the torcular and the bone, so that it is desirable not to cut away the external occipital protuberance, nor is there any disadvantage in leaving it. When a dural vein is torn, bleeding can be readily stopped by the application of a small pad of muscle cut from the flap as advised by Horsley. After a few minutes of gentle pressure the muscle plug adheres quite firmly. It is very undesirable to use a gauze plug for hæmorrhage, as the wound should always be closed completely. Bleeding in the deeper parts of the wound can generally be stopped by gentle and repeated packing with gauze dripping with hot saline solution.

(c) *Removal of the tumour.*—Cysts of the posterior fossa are quite simple to deal with by evacuation and partial or complete removal; localized tumours of the lateral lobe can also be excised with comparatively little risk. It is the tumour of the cerebello-pontile angle which gives rise to the greatest difficulties. In these cases full bilateral exposure is necessary.

The dura in the foramen magnum is incised first and the lower edge of the cerebellum raised so as to allow fluid to escape from the 4th ventricle. If a free escape of fluid does not occur and the tension remains high, the lateral ventricle should be tapped. The scalp above the incision is retracted and a small hole drilled in the skull about 1¼ in. above the superior curved line and ¾ in. from the middle line. A blunted needle is passed slightly upwards and outwards through the opening until the ventricle is entered, usually within 2 in. of the surface. The needle is left in position until the tumour has been removed. The hemisphere on the affected side is dislocated towards the middle line, a manœuvre rendered much easier if the tension has been relieved by evacuation of fluid. A certain amount of hæmorrhage occurs from veins passing from the hemisphere into the lateral sinus. The tumour is finally reached, and is recognized by its situation, its firm consistence, and its smooth whitish capsule containing small branching vessels. The removal of the tumour intact is now generally regarded as too dangerous to be justified. The capsule should therefore be opened and the substance of the tumour excavated from within it by suitable forceps and scoops. If the capsule is allowed to remain a recurrence of symptoms may be expected within a few years. If the emptied capsule is removed, with whatever cautious gentleness, there is a considerable risk of troublesome hæmorrhage and of damage to the facial nerve The certainty of cure to be obtained by a successful removal of the capsule would probably be accepted by most patients as adequately compensating even for a permanent facial paralysis. Moreover, it must be remembered that a facial paralysis following this procedure may recover completely. A full discussion of this difficult

question is not possible here. My personal experience inclines me to the view that the removal of the capsule should generally be attempted. There is no doubt that it can be carried out in some cases with complete success.

The dangers of the operation for removal of this type of tumour are undoubtedly great, but if anything is done a radical operation should be attempted, since the condition is, as a rule, not relieved by a decompression. (Fig. 738, p. 535.)

(*d*) *Escape of cerebro-spinal fluid.*—Leakage of cerebro-spinal fluid after these operations is a serious complication. It can usually be avoided if careful attention is given to the suturing of the muscles and of the skin. Should escape of fluid persist for more than a few days the opening through which it occurs must be stitched up.

Operations for pituitary tumours.—Of the numerous methods of approach to the pituitary body which have been suggested and practised, the nasal has proved to be by far the most successful. At first routes were used which led through the upper part of the nasal cavity, rendering necessary temporary reflection of the nose itself. These have been more or less replaced by the septal method devised by Hirsch. This involves a submucous resection of the septum until the body of the sphenoid bone is reached, when the sphenoidal sinus is opened and the floor of the sella turcica, usually bulged by the tumour, is removed. The dural covering of the hypophysis is then incised, and the condition met with treated as far as is possible. This operation should not be done unless enlargement of the sella turcica can be demonstrated by radiography and distinct pressure symptoms are being produced. By its means cysts can be evacuated, adenomatous growths partially removed, and pressure relieved. Possibly, also, active acromegaly can be arrested.

The danger of the operation is not very great, but its technical difficulties, chiefly in the matter of orientation, are considerable. It may be carried out through the anterior nasal aperture or through an intrabuccal incision at the attachment of the upper lip. When the tumour has extended widely into the cranial cavity beyond the sella turcica the nasal operation is likely to effect but little relief. Another method of approach that has been practised is through an opening in the temporal fossa with elevation of the temporal lobe. It is unusual for a tumour to be accessible by this route, but occasionally a cyst can be evacuated. The operation may, however, prove valuable as a means of decompression, especially if bilateral openings are made, and thus be used as a preliminary to the nasal operation in very severe cases. Finally may be mentioned the frontal route. In this the superior margin of the orbit with part of the frontal bone above it is temporarily resected, the roof of the orbit is cut

away, the dura and frontal lobe are raised, and the pituitary body is approached between the optic foramina.

HYDROCEPHALUS

It is not possible here to do more than define the broad principles on which the treatment of hydrocephalus should be considered. In doing this, two groups of fundamental facts must be kept in mind—first, the normal course through which the cerebro-spinal fluid passes, and secondly, the relation of the cerebro-spinal fluid to the other fluids and tissues of the body.

1. **The course of the cerebro-spinal fluid.**—The fluid is secreted by the choroid plexuses of the lateral, 3rd, and 4th ventricles. Probably less than a quarter is produced in the 3rd and 4th ventricles, so that the lateral ventricles are by far the most important source. It occasionally happens that during an operation a clear and close view of a choroid plexus is obtained. The appearance of the fluid in rapidly forming drops on the surface of the plexus is then easily visible. Passing along the central canal of the brain, the fluid leaves the 4th ventricle by the foramina of Magendie and Luschka, and enters the large subarachnoid cisterna magna. From here most of it travels forward in the subarachnoid cisterns of the base and thence spreads upwards over the cerebral hemispheres, where in the subarachnoid network over the sulci it is absorbed into the veins. A small proportion passes downwards from the cisterna magna through the foramen magnum and is absorbed from the subarachnoid spaces of the cord. The main stream, however, is towards the surface of the hemispheres, and if this is obstructed at any part of its course hydrocephalus results.

2. **The relation of cerebro-spinal fluid to other fluids and tissues of the body.**—It is a fundamental property of all neural tissues that they cannot be brought into direct contact with non-neural tissues without setting up reactions in the latter. It is for this reason that the whole nervous system is everywhere insulated from the rest of the body except at the actual points where its specific effects are to be produced. The cerebro-spinal fluid shares this property of the neural substance; wherever it is found it is necessarily enclosed by a dura mater, the essential characters of which are a smooth glistening inner surface, an outer surface which is differentiated from the surrounding tissues, and a dense impervious substance. If through operation or accident the normal dura is opened and the contained fluid comes into contact with the extradural tissues, a new dura is rapidly formed. Thus the contact of cerebro-spinal and somatic tissues is broken and impenetrably sealed off. If the fluid escapes into the tissues under pressure the same reaction

occurs, and though a large collection may form, it none the less comes to be enclosed by a dural sac. From these considerations it is plain that cerebro-spinal fluid which is accumulating through the closure of the normal channels of absorption cannot be got rid of by continuous drainage into the extradural tissues; whether the drainage be into the subcutaneous tissues, into serous cavities, or through a grafted vessel into the blood-stream, the inevitable reaction must occur and the new channel be quickly and impenetrably closed. This physiological fact at once disposes of a large number of technically ingenious methods that have been invented for the treatment of hydrocephalus. It seems clear, moreover, that the subdural space is incapable of absorbing more than an inconsiderable amount of cerebro-spinal fluid, so that it is at any rate highly improbable that any of the methods of subdural drainage can be permanently effective.

Whether obstruction to the outflow ever produces suppression of the secretion of cerebro-spinal fluid, as sometimes happens in the case of the kidney, is not clearly known, and though the question is one of theoretical interest it can be of little practical importance in any given case of hydrocephalus, since the condition itself is evidence enough that secretion continues.

The therapeutic principles to be deduced from these physiological considerations are as follows:

(*a*) The normal channels are the only ones through which absorption of cerebro-spinal fluid can occur.

(*b*) If an obstruction of these channels can be adequately and permanently relieved in a case of hydrocephalus, a cure will result.

(*c*) If an obstruction to the channels of absorption that is causing hydrocephalus cannot be relieved, the only hope of cure will be in diminishing the supply of fluid at its source. This has been done by removing the choroid plexuses of the lateral ventricles.

Varieties of hydrocephalus.—It is convenient to distinguish broadly three etiological types of hydrocephalus—(1) in which there is some congenital defect in the formation of the channels by which the cerebro-spinal fluid should pass from the choroid plexuses to the surface of the hemispheres and obstruction is present at birth; (2) in which, as the result of meningitis, the foramina in the roof of the 4th ventricle, the basal cisterns or the channels leading from them are obstructed, and (3) in which the pressure of an intracranial tumour obstructs the flow of fluid either within the central canal of the brain or at the foramina of exit from it. In order to determine the possibilities of treatment in a given case, it is obviously necessary that a precise diagnosis of the seat of the obstruction should be possible. The only methods which offer to afford this are those introduced by Dandy, to whom we also owe the formulation of the first theoretical and prac-

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the condition found. A grossly damaged and disorganized area of the brain should be excised. If the exploration is negative but the history of a severe head injury is definite, the possibility of there being an old contrecoup lesion at a point diametrically opposite should be considered. When the fits are of the Jacksonian type, operation should certainly be undertaken, and if a scar or cyst in the brain is found it should be excised, provided this can be done without producing serious disability such as hemiplegia or aphasia. In all cases of this class some improvement may be expected, and sometimes the results of operation are very good. As has already been mentioned, in certain cases of epilepsy the presence of an opening in the skull seems to have an influence on the occurrence of the fits. In such cases a plastic operation for closure of the opening should be considered. It must be admitted, however, that when once the epileptic habit has been established it is often impossible to eradicate it, even when what appears to be the originating lesion is found. The difficulties of dealing with traumatic epilepsy should serve to emphasize the necessity for operating on recent injuries of the brain, so that the disturbance may be dealt with before it has set up the instability of which epilepsy is the expression.

TRIGEMINAL NEURALGIA

Definition and nomenclature—Trigeminal neuralgia is a chronic progressive disease of which the sole primary symptom is pain limited to the area of distribution of the 5th cranial nerve. It is characteristic of the disease that there is no reduction of the sensory or motor functions of the nerve, and that no causal relation can be demonstrated with any focus of peripheral irritation such as an infected nasal sinus or a diseased tooth; "epileptiform neuralgia" and "tic-douloureux" are terms that doubtless owe their origin to the periodical and recurring outbursts of darting pain of which the disease consists, and in some degree also, perhaps, to the partly voluntary movements of the affected side of the face with which the spasms of pain come to be associated "Major neuralgia" is a name also sometimes used to indicate the inveteracy and progressiveness of the condition, as distinguished from the "minor" though not necessarily less severe neuralgia set up by, and curable by the removal of, peripheral irritation. The term trigeminal neuralgia, although logically descriptive of any painful affection of the 5th nerve, has gradually become limited to the disease under consideration here, and will be used in this chapter in that sense only.

Onset, course, and symptoms.—Trigeminal neuralgia is a disease of middle life. *Occasionally, however, it begins in the young*

adult, so that an early onset, while rendering necessary special caution in diagnosis, is by no means in itself conclusive evidence against a given facial neuralgia being of the major kind. The two sexes are about equally affected.

The pain is at first limited to one or other of the three divisions of the 5th nerve (Fig. 744), and tends to spread throughout the distribution of the one branch before extending to the next. A pain

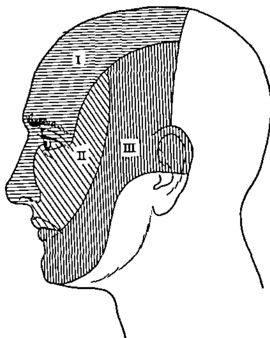


Fig. 744.—Cutaneous supply of 5th nerve.

involving from the very first more than one division is, as such, unlikely to be a true trigeminal neuralgia

The primary onset of pain is usually in the second division, less commonly in the third, and rarely in the first. Onset in the second or third division is so much more common than onset in the first division that cases of supposed trigeminal neuralgia beginning in the first division should always be regarded with some suspicion In the ordinary case of primary affection of the second division the pain is often first felt at the junction of the upper lip and nose, and from here it gradually spreads throughout the superior maxillary area of distribution, involving the upper teeth, the palate, the upper lip, the lower eyelid, and the temporo-malar region. Hypersensitiveness of the skin and mucous membrane in the affected area develops with the appearance of the

pain. It is not usually uniform, but seems to be most marked in the regions where the pain is especially felt, as for example at the junction of the nose and the cheek. The tender areas are extremely sensitive to light and accidental stimulation, while they will often tolerate firm and deliberate pressure. Such pressure sometimes gives a certain amount of relief to the pain, and the patient may develop the habit of pressing upon some limited area of the face until the skin becomes seriously excoriated.

When the third division is affected the chief seats of pain are the lower lip, the lower teeth, the oral part of the tongue, the external auditory meatus, and the temporal region as far back as, and including, part of the ear.

The course of the disease is very characteristic and is made up of attacks and intermissions. The attacks last from a week or two to several months. During a true intermission the patient is quite well and is not only free from pain but need take no precautions to prevent it from coming on.

During the attack there is often a continuous sense of discomfort in the affected part, and sometimes a steady, though not severe, aching pain. There is, moreover, throughout the attack a constant liability to the onset of the characteristic bouts of violent pain, either spontaneously or as the result of accidental or unavoidable stimulation. Each bout, which may last for a period of from a few minutes to as much as an hour, is made up of a series of rapidly repeated momentary stabs of agonizing severity along the distribution of the affected part of the nerve. Almost all patients agree upon this stabbing, darting quality of the pain, and compare it with what might be expected from a red-hot needle being repeatedly stabbed into the flesh

A bout of pain may be precipitated by almost any stimulation of the affected part, such as a light accidental touch, a draught of cold air, or the movements of mastication, swallowing, or speech. On this account the patient may be unable to wash his face, may *seriously* restrict his food, and may be unable to speak more than a few words at a time. *His aspect in such a bout of pain is very characteristic.* At the onset he is suddenly struck silent and still, the face flushes and the eye waters, and the lips, also on the affected side, are thrown into slow chewing movements. These movements are, of course, no essential part of the disease and, although they tend to become habitual, and thus unconscious, are of voluntary nature and origin. After a few minutes of this intense suffering there is usually a short remission, and then another bout, and so on for an hour or more. Many patients find that quiet, absolute immobility, and warmth may ward off the pain for short periods, but its general occurrence and distribution are entirely uncontrollable except by powerful narcotic drugs.

The attacks tend with the lapse of time to become longer, and the intermissions shorter and less complete. The pain may remain limited to one division, or even part of a division, for many years, but in general there is a tendency for its territory to enlarge until the whole nerve is involved. It is probable that in a few cases spontaneous recovery occurs; this is certainly very rare in the developed disease, which usually has an unlimited and progressive course. It is remarkable how common it is for the subjects of trigeminal neuralgia to have exceptionally vigorous general health, and to resist weakening by the pain and its secondary effects through long periods of years Many cases, however, result in morphinism or end in suicide.

Pathology.—Trigeminal neuralgia has no characteristic morbid anatomy. It is common for the Gasserian ganglion in advanced cases to show a certain amount of fibrosis and to be abnormally adherent to the walls of the cavum Meckelii. It is not possible at the present time to connect these variable changes with the causation of the disease.

The very great frequency with which the pain begins in the second and third divisions suggests that it bears some relation to the teeth and possibly has an infective origin It seems certain that the disease is at first seated in the peripheral part of the nerve, since a peripheral operation destroying the affected branch by injection or removal is sometimes permanently successful. Moreover, when a temporarily successful operation is followed by a recurrence the pain is preceded by a return of sensibility to the part. There is no evidence, however, of any relation between disease in the area of the 5th nerve and trigeminal neuralgia. As far as we know, dental disease does not predispose to it in any way, and the greatly increased attention given to oral and dental hygiene of recent years does not seem to have produced any corresponding diminution in its incidence. There are many forms of peripheral lesions, nasal and dental, which cause pain resembling that of trigeminal neuralgia; such pain, however, is always brought to an end by the removal of its cause, and shows no tendency, however long it has lasted, to pass over into the more serious complaint

When trigeminal neuralgia is compared with other painful affections of the nerves it shows certain characteristics which are peculiar to itself. It is the only well-marked persistent and progressive condition which, however prolonged and severe, is never accompanied by any reduction in functional activity, sensory or motor. It is clear, therefore, that the process underlying it is in no way destructive, as are in their degree all known forms of neuritis This applies even to the so-called ascending neuritis that is known to occur as a rare complication of small infective lesions of the finger-tips. This condition,

which must probably be regarded as an organic affection of the nerves, resembles trigeminal neuralgia rather closely in the severity of the pain and the character of the tenderness, but usually shows a definite reduction in the sensibility of the affected parts. The lesion of trigeminal neuralgia, then, is singular in having no destructive effects on the nervous tissues, and is possibly of such a nature as to act selectively on the pain fibres of the nerve. A further peculiarity of the disease, in comparison with similar conditions, is that in the vast majority of cases, though perhaps not quite invariably, it can be completely relieved, at however advanced a stage, by section of the sensory root of the 5th nerve. Posterior root section for painful conditions of the peripheral nerves, where the nerve substance is involved, is, as is well known, by no means so satisfactory. It is unfortunately not possible to determine whether this difference is due to the very obvious anatomical differences in the two cases, or whether the ascending changes in damaged peripheral nerves can pass beyond the posterior root ganglia, while those of trigeminal neuralgia are practically always *arrested at the Gasserian ganglion*

In reviewing such pathological indications as we possess in relation to trigeminal neuralgia, it must be admitted that our knowledge is extremely meagre, and unable to carry us beyond the following propositions. It is reasonably certain that the causal lesion begins in the ultimate ramifications of the nerve, and that it tends to spread centrally but not to pass the Gasserian ganglion, that it is unlike any other equally well-marked disease of the nerves in being wholly without destructive effects, and that it is not connected with any known diseased condition in the parts to which the affected nerve is distributed. It is possible that the lesion originates in connexion with the mouth or teeth, and that it has the power of acting selectively on the pain fibres of the nerve.

Diagnosis.—In well-marked cases trigeminal neuralgia is capable of direct and positive diagnosis. The characteristic features are: (1) The pain is strictly limited to the trigeminal area of one side; the only exceptions to this are that in rare cases the disease is bilateral, and that in severe cases of the ordinary kind the patient is apt to have a certain amount of dull pain in the occipital region—possibly through implication of the meningeal branches of the nerve; (2) the distribution of the disease into what have been called attacks and bouts of pain, and the quality of the pain itself; (3) the total absence of diminished sensibility or motor power in the nerve. In painful affections not showing all these characteristics strongly marked the diagnostic problem is a complicated one A broad distinction can generally be made at once, whether in a given case the pain is essentially trigeminal in distribution or not.

(A) **Pains of distribution other than trigeminal**.—Many forms of neuralgia in the head have been described which are supposed to originate in other nerves than the 5th. Pain in and about the ear, associated with or following herpes in the external meatus, has been ascribed to disease of the geniculate ganglion of the facial Pain in the throat and pharyngeal part of the tongue, aggravated by and greatly interfering with swallowing, has been regarded as a neuralgia of the glosso-pharyngeal nerve. Disease of the spheno-palatine ganglion or its connexions has been supposed to account for certain cases of deep-seated pain in the maxillary region and lateral aspect of the nasal cavity. None of these conditions is as yet sufficiently separated out as a clinical type to render useful discussion of its diagnosis possible here. It is necessary, however, to recognize that forms of neuralgia do occur, though rarely, which are persistent and distressing, and might be regarded as atypical cases of trigeminal neuralgia, though they are in fact not to be relieved by the most radical measures directed towards the 5th nerve.

It must be remembered in connexion with neuralgias of the head that the uppermost three cervical nerves take part in the supply of the head and face The skin over the angle of the jaw, a large part of the external ear, and all the scalp behind the line of the external meatus have such a spinal nerve supply. In cases where these nerves are involved in or near the intervertebral foramina by osteitis, arthritis, or neoplasms of the spine, a superficial resemblance to trigeminal neuralgia may be produced. The actual distribution of the pain, however, and the early development of sensory defects make the diagnosis easy.

(B) **Pains of trigeminal distribution**.—Affections of this kind are divisible into four well-marked types. The differentiation of these is usually easy, but is occasionally exceedingly difficult:

i. Trigeminal neuralgia (major neuralgia).
ii. Herpetic neuralgia.
iii. Neuralgia associated with a definite peripheral lesion—sometimes called minor neuralgia, not as less painful but as more tractable
iv. Neuralgic pain due to pressure on the nerve-trunk or a main branch.

Herpetic neuralgia.—This is due to and persists after herpes in one or other division of the nerve. It is sometimes extremely severe, and is often classified with true trigeminal neuralgia. As, however, it has a definite morbid anatomy and is always associated with changes in the corresponding part of the ganglion, it should, of course, be treated as a distinct disease. It affects the ophthalmic division far more commonly than any other; its nature is usually detected

by the history of ophthalmic herpes (though the acute *disease* may not at the time have been recognized as such), by the presence of herpetic scars, and by the presence of slight but definite sensory defects.

MINOR NEURALGIAS.—These make up what is probably the commonest and in some ways the most important group of painful affections of the face and head. The pain is often very severe and distressing, and may, while it lasts, be quite as incapacitating as true trigeminal neuralgia. In general it may be said that the pain does not tend to be grouped in definite attacks *and intermissions—though* there are exceptions to this—but is more persistent, and does not usually have the quality of needle-like and recurrent stabbing. The true minor neuralgia due to an irritative peripheral lesion is unaccompanied by any sensory or motor defect, and is usually fairly definitely limited to the trigeminal area. It is not, however, as a rule, quite so rigidly restricted to this area as is the major neuralgia. Of peripheral lesions that cause it, infective conditions of the nasal sinuses and *diseases connected with the teeth are by far the commonest. Foci* of gummatous infiltration and sclerosis in the cranial or facial bones are an occasional cause.

Neuralgia of nasal origin.—Many conditions in the nasal cavities have been found to be responsible for facial neuralgia, and the determination of the diagnosis in a given case will usually be a question for the expert rhinologist. Certain considerations are, however, of general interest. The severe and more persistent types of pain are *likely to be due to infection of the antrum or the frontal sinus.* In such cases a distribution of the pain into attacks and remissions like those of a major neuralgia may be produced by the sinus infection being exacerbated whenever the patient gets a cold in the head, and dying down again for a time. In some cases of sinus disease, moreover, the pain shows a remarkable tendency to come on every day at precisely the same time, to last a few hours, and then completely to disappear. This course is sometimes followed day after day with *the greatest* regularity, and has been known to give rise to the suspicion that the pain could not be of organic origin. The pain of antrum disease usually affects the distribution of the second division, and may be *complicated in longstanding cases by actual hypœsthesia* in the area of the infra-orbital nerve through pressure on the canal. Frontal-sinus disease causes supra-orbital neuralgia, and is usually accompanied by local tenderness not due to the nerve condition. Antrum disease, once suspected, can always be established or excluded quickly and with certainty; frontal-sinus disease is not, perhaps, so easily decided upon, and in a strongly suspicious case it would seem occasionally to be justifiable to explore the sinus from without, even in the absence of the usual rhinological evidence.

Neuralgia of dental origin.—Here again the diagnosis must necessarily, as a rule, be in the hands of the especially expert. Of the conditions that are apt to come before the general surgeon in the first instance, those connected with imperfectly erupted and impacted wisdom teeth are perhaps the most common. They need not be further discussed here. There is a much less common condition of *painful sclerosis round a tooth socket* which sometimes gives rise to a persistent and severe neuralgia. It occurs in the lower jaw and follows the normal extraction of one or more teeth; the muco-periosteum heals well but becomes exceedingly sensitive and the focus of neuralgic pain which persists and spreads. A radiogram shows a patch of irregular sclerosis surrounding the socket of the extracted tooth. Free removal of the sclerosed bone usually gives complete relief.

PAIN DUE TO INVOLVEMENT OF THE NERVE-TRUNK OR BRANCHES —The recognition of this type of pain is especially important, as it is usually due to very grave disease. It is convenient to consider the anatomical course of the nerve in three stages—in the posterior fossa between the pons and the superior border of the petrous bone, in the middle fossa from the edge of the petrous to the three openings of exit for the branches, and in the three branches themselves from the foramina onwards.

In the posterior fossa of the skull the nerve is directed forwards from the pons to the opening of the cavum Meckelii. It lies close below the anterior part of the tentorium, the facial and auditory nerves as they enter the internal auditory meatus being below and behind it It is therefore apt to be pressed on by tumours developing at the antero-inferior surface of the cerebellum. Such tumours may be meningeal endotheliomas, but the most common and most important is the auditory fibroma. Of the clinical evidences of this tumour the trigeminal symptoms may be very important. Neuralgic pain, reduced sensory acuity, and depressed conjunctival reflex are the most important of these. The pain is not usually severe, and all the symptoms may be slight, transient, or only intermittent in their appearance There is not likely, therefore, to be any difficulty in making the diagnosis from trigeminal neuralgia except in the rare cases where the pain is severe

In the middle fossa of the skull the nerve and ganglion may be involved in endotheliomas either of the meninges or primary in the ganglion itself. The diagnosis from trigeminal neuralgia depends on reduced sensory and motor activity in the distribution of the nerve; other evidences of intracranial tumour will usually be present in the later stages only.

Involvement of the branches of the nerve.—The ophthalmic division is so rarely involved as not to need consideration here. The superior

Injection aims at forcing alcohol under some pressure into the substance of the nerve. When successfully carried out it destroys the conducting elements over a considerable length of their course. If it has been done above the affected part of the nerve, anæsthesia of the painful area and complete relief of pain follow at once. The changes it produces in the nerve do not prevent regeneration, which follows in due course. With return of sensibility to the anæsthetized area a recurrence of pain may be expected sooner or later. A satisfactory injection into one of the main divisions and not affecting the ganglion may be counted on to give freedom from pain for about twelve months. Alcohol may also be injected into the ganglion itself, either directly or by spreading along the nerve. In this way the ganglion cells are more or less completely destroyed and regeneration is correspondingly interfered with. In actual practice it is probable that complete destruction of the ganglion cells is rarely if ever obtained. There is no doubt, however, that satisfactory ganglion injection tends to produce a much more lasting effect than mere injection into the nerve.

The disadvantages of injection are considerable. The procedure is very difficult, and in the most expert hands uncertain. Repeated attempts are often necessary before the desired result is attained. If it is done without a general anæsthetic it is apt to be painful and distressing to the patient; if it is done under general anæsthesia the difficulty of finding the nerve is increased. In certain cases where there are special reasons for injection the nerve or even ganglion may be exposed and then injected. This applies especially to the treatment of the second side in bilateral cases.

Technique of subcutaneous injection.—The method, especially when applied to injection of the ganglion, is by no means without risk and should not be used by those who have had no opportunities of studying it on the cadaver. Only a very summary description of it, therefore, will be given here.

Apparatus required.—A straight needle 12 cm. long, 1·75 mm. in diameter, with a blunt stylet which is flush with the needle when pushed home. The needle is graduated in centimetres for 6 cm. from the point. For injection of the solution a 2-c.c. syringe is employed The solution is:

Cocaine hydrochloride	0·1 grm.
Distilled water	2 0 c.c.
Alcohol	13·5 ,,

Method of injection.—Local anæsthesia [illegible]

[illegible] pain is felt in the distribution of the branch involved. Two c.c.

of the solution is then injected. If the injection is successful, immediate analgesia to pin-prick results.

Route: (a) Maxillary division at foramen rotundum.—The needle is inserted at the lower border of the zygoma 0 5 cm. behind a perpendicular through the posterior border of the orbital process of the malar. It is directed inwards

5 cm. from the surface of the skin. The 6th nerve may be injured by going too far in, but if the patient is directed to look towards the operator the injection can be stopped at once if any weakness of abduction is noted. Difficulty may be introduced by variation in the shape and position of the coronoid process.

(b) Mandibular division at foramen ovale.—The needle is inserted at the lower border of the zygoma, 2 5 cm. in front of its anterior root. It is directed inwards with a slight inclination backwards and upwards until it strikes the posterior border of the external pterygoid plate at an average depth of 4 cm. From this point it is worked backwards until it reaches the nerve, which lies i

pterygoid plate.

may strike its bo

mouth to give more space between jaw and zygoma. In favourable cases the ganglion itself can be injected by this method.

Operation.—Two types of operative treatment are available—peripheral and central.

Peripheral operations, which are always in the nature of a resection or avulsion of as much of the nerve as can be got out, have of recent years to some extent been supplanted by injection The third division is very unfavourably placed for resection, and should always in the first instance be dealt with by injection, for which it is by far the most suitable branch. The second division is less certainly reached by injection, and lends itself readily to treatment by operation Avulsion of the second division after it has been followed back in the infra-orbital canal as far as possible is a simple operation, and very satisfactory in suitable cases. The use of it should be limited to cases where the pain is in the area of the infra-orbital and anterior dental branches alone, as it is not always possible to be sure of tearing the nerve away behind the origin of the temporo-malar and posterior dental branches. The ophthalmic division is inaccessible to satisfactory injection, and only its frontal branch can be dealt with by a peripheral operation. Such an operation is perhaps occasionally justifiable, but cases of a suitably localized supra-orbital neuralgia are rare. It is, of course, obvious that no peripheral operation can give relief in a postherpetic neuralgia, since the causal lesion is in the ganglion.

Central operations.—The only operation designed to interrupt the whole nerve that should be done is division of the sensory root between the ganglion and the pons The intradural method of tri-

geminal neurectomy planned and carried out by Horsley is no longer used, the modern operation being a development of the Hartley-Krause method of exposing the ganglion. (Fig. 745.) The approach is therefore through the temporal fossa above the zygoma, and a bone-flap may be used. The foramen spinosum is plugged, the middle meningeal artery divided, and the foramen ovale defined. The edge of the dura running upwards and backwards from this foramen is incised and the root of the ganglion exposed. When the full breadth of the root has been cleared and defined, a hook is passed round it and it is drawn from its pontine attachment. This operation is less troublesome than the old ganglion operation, and it is equally radical. It has, of course, the disadvantage of anæsthetizing the cornea and of paralysing the masticatory muscles. Attempts to spare the motor root usually fail, and may lead the surgeon to spare some of the sensory fibres. In favourable cases the operation is a relatively easy one; the chief difficulty likely to be met with is that the sensory root in the cavum Meckeli, instead of being a separate, clearly defined structure, may be so incorporated with the surrounding dura that its limits are indistinguishable. An incomplete operation is then apt to result.



Fig. 745.—General relations of the Gasserian ganglion.

A third class of operation, intermediate in character between the true central and peripheral types, is the partial resection of the *Gasserian ganglion*. The ganglion comes into such close relation with the cavernous sinus that a complete resection of it, including the ophthalmic part, is extremely difficult and dangerous. The part of the ganglion corresponding with the third division is quite free of the sinus, as is usually the superior maxillary part. The three segments of the ganglion are not intermingled with one another, so that it is possible, for example, to remove the part corresponding with the third division with a reasonable probability of completeness, and at any rate a considerably less likelihood of regeneration occurring than if the inferior maxillary nerve itself had been divided alone. Such an operation has a restricted but definite usefulness It is likely to

produce a far more lasting result, but is not so very much more serious than a peripheral operation. It is particularly appropriate for an inferior maxillary neuralgia which has relapsed early after injection, or in which injection has failed.

The *choice of the various methods* to be used in a given case cannot, of course, be laid down precisely, and the following general statements must be taken as subject to modification in special circumstances and as representing only what seems best in a broad way at the present time.

Central neurectomy and *injection of the ganglion* are theoretically equivalent to one another. As regards the liability to postoperative eye complications there is nothing to choose between them, and, while the neurectomy is slightly more dangerous, the injection is decidedly *less certain. In competent hands there can usually be no objection* to injection first being tried where neurectomy would otherwise be indicated.

When the ophthalmic and one or two of the other divisions are seriously involved, and injection of the ganglion has failed or given only a short freedom from pain, neurectomy is obviously the only treatment. The same rule would apply to ophthalmic neuralgia alone if the diagnosis were regarded as certain and the pain as sufficiently severe and persistent.

With pain limited to the two lower divisions alone, the choice would be among neurectomy, partial resection of the ganglion, and injection On the whole it seems that here neurectomy is the right treatment, especially if injection has failed.

Pain definitely limited to the inferior division calls for injection of the nerve at the foramen ovale or partial resection of the ganglion.

Pain limited to the second division calls for injection of the nerve at the foramen rotundum or, if the posterior dental is not involved, *avulsion of the nerve.*

In cases of bilateral neuralgia the great object must be to avoid paralysis of the masticatory muscles on both sides. If one side has been dealt with by central neurectomy, as will usually be best, the most satisfactory treatment of the other probably is to expose the ganglion by the temporal route in order that it may be injected with the greatest attainable precision and certainty.

Postoperative complications and results.—*Neuropathic keratitis* may occur in any patient in whom the cornea has been rendered analgesic. The greatest *liability exists within the first few weeks* after the operation, and it decreases rapidly after the first three months. It is necessary to protect the eye very carefully during the operation and *during* convalescence. Should keratitis supervene, prompt freshening *and* suture of the central part of the palpebral fissure always arrests

it. The cornea must be kept thus protected for many months. It is possible that central neurectomy is less apt to be followed by keratitis than is either injection or excision of the ganglion.

Patients often find the profound anæsthesia following neurectomy a source of discomfort. They often complain of unpleasant creeping sensations in the anæsthetic skin, and that the same side of the mouth and tongue feels uncomfortably swollen.

The relief of pain following neurectomy is usually complete and permanent. In very rare cases the operation fails to give relief, though it produces satisfactory anæsthesia and the diagnosis seems to have been accurate. Another rare occurrence is for an apparently satisfactory neurectomy, in which the whole root has been clearly seen, to produce an incomplete anæsthesia. In one similar case in my experience there was evidence that the nerve had pierced the dura in more than one trunk.

To illustrate, in conclusion, the extreme inveteracy of the disease, and the extraordinary regenerative vigour of the nerve, a case may be mentioned which has come under my own observation in which, after a successful removal of the Gasserian ganglion followed by profound anæsthesia, there was complete relief of pain for no less than eleven years. At the end of that time severe pain of a typical kind reappeared, and it was found that there had been a considerable return of sensibility.

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THE SPINE AND SPINAL CORD

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SURGICAL ANATOMY

Superficial relations of the spine and spinal cord.—It is of essential importance to the surgeon to be able to expose with reasonable precision any given segment of the spinal cord. The first step in the rather complicated process necessary for this is the identification of the various parts of the spine. The only parts that can easily be felt in ordinary clinical circumstances are the tips of certain spinous processes which are subcutaneous in the median furrow of the back. The uppermost spine to form a visible projection under the skin is usually the 7th cervical; it is to be remembered, however, that the 1st dorsal makes a larger projection than the 7th cervical, and that when the neck is much bent the 6th cervical comes to the surface. The 7th cervical and the succeeding spines are subcutaneous and can be counted in series, so that each one down to the 5th lumbar can be identified. In the dorsal region the tips of the spines are very close to one another, and difficult to distinguish with certainty. The usual custom of finding a given spine by counting upwards from below as well as downwards is here, therefore, especially necessary.

As starting-points for counting the spines upwards, two landmarks are available. Of these, the 12th rib when normally developed is a trustworthy guide to the 12th dorsal spine The normal 12th rib projects about an inch beyond the outer edge of the erector spinæ muscle, and its free end is easily to be identified. Often, however, the 12th rib is very short, and then it is concealed from palpation by the erector spinæ. When, therefore, the lowest [illegible] it is probably the 11th. and th[illegible] ing on [illegible] part of the iliac crest on each side. This line passes through the [illegible] between the 3rd and 4th lumbar spines, and close to the latter.

The second step in localizing in relation to the surface any given segment *of the cord is to establish the relation of the spinous processes to the various* segments. The segments of the cord are named from the spinal nerves attached to them, so that what in practice has to be fixed is the relation of the spinous processes to the origins of the nerves.

The level at which the spinal cord ends below cannot be defined with minute precision, because the conus medullaris tapers into the filum terminale, and because the relative length of the cord varies to some extent from subject to subject. For practical purposes, however, accuracy is

adequately served by defining the termination to be behind the body of the 1st lumbar vertebra and nearer the lower than the upper border. This amounts to saying that *the cord ends below at the level of the space between the 12th dorsal and 1st lumbar spines.* Since the cord does not extend below the 1st lumbar vertebra, while it gives off nerves that traverse all the intervertebral foramina as well as the lower opening of the spinal canal, the nerves have to travel a certain distance between their spinal origins and their exits from the canal. The length of the intraspinal course of the nerves increases progressively and fairly regularly from above downwards, but it varies so much that the rules to be laid down for determining it must be regarded as having no more than a rough practical usefulness.

1. The intraspinal course increases fairly regularly for the cervical and dorsal nerves. In the upper cervical region it is not greater than the depth of one vertebra, and is therefore unimportant in regard to localization. In the lower cervical region each nerve arises about opposite the second spine above its place of exit. Thus the 6th cervical nerve issues between the 5th and 6th cervical vertebræ, so that the 4th spine is the second above its place of exit and indicates the level of its origin.

In the upper half of the dorsal region the origin of a given nerve is about opposite the 3rd spine above the foramen of exit. Thus the 5th dorsal nerve, issuing between the 5th and 6th dorsal vertebræ, has its origin at the level of the 3rd dorsal spine. In the lower half of the dorsal region the fourth spine above the place of exit marks the level of origin, so that, for example, the 9th dorsal nerve arises from the cord opposite the 6th dorsal spine.

These estimates of the situation of the dorsal segments of the cord can be accepted for practical purposes only with an allowance for an error of at least one spinous process each way. This uncertainty is chiefly due to the great and variable length and obliquity of the dorsal spines. It is to be remembered also that at the 8th cervical nerve the relation of the nerves [illegible] issues *above* [illegible] s reversed. [illegible] ar segments [illegible] al segments [illegible] between it and the 1st lumbar spine.

The spinal muscles and the neural arches.—Certain features of these parts call for comment in relation to the surgical exposure of the spinal cord. The only method available is the removal, by the operation of laminectomy, of the posterior wall of the spinal canal in the region which is to be exposed. In this operation the extensor muscles are separated from the spinous processes and laminæ, and retracted outwards on each side from the vertebral groove. These muscles are traversed obliquely backwards and inwards by the large posterior branches of the intercostal and lumbar vessels, which bleed freely during separation of the muscles from the bone. Owing, however, to the oblique intramuscular course of the vessels, bleeding from them stops when the muscles have been detached and are firmly and steadily retracted.

In the dorsal region the vertebral groove is comparatively open and shallow, the muscles are largely tendinous and, therefore, not bulky, the laminæ relatively superficial and the spine normally convex posteriorly. The operation of laminectomy is therefore least difficult here. In cases of injury or disease when the normal convexity is sharply exaggerated the

spinal canal is brought very near the surface. Special care is then necessary that it is not opened unawares and accidental injury inflicted on the cord. Owing to the nearness to the pleural cavities of the parts dealt with *in a dorsal* laminectomy, considerable suction is exercised through the wound during inspiration and may be disturbingly evident. If the breathing should be laboured, air may be heard being aspirated into the tissues about the spine, into the spinal canal, and even into the veins. These disconcerting sounds may even suggest that the pleura has been *accidentally damaged*, but such a possibility is very remote, except perhaps in cases of extreme deformity from destructive disease. We have never seen any serious consequences of these suction effects. It is one of the advantages of intratracheal administration of the anæsthetic that no such phenomena can occur.

In the **cervical** region the vertebral groove, though flat and open, is thickly clothed with fleshy muscles, the spine is concave backwards, and the laminæ are crowded together and tend to overlap one another. The *characteristic* anatomical difficulty of this region is in obtaining access to the 3rd and 4th laminæ, which are sheltered by the big and oblique spine and arch of the axis. Proper exposure of these laminæ renders necessary a long incision carried well up on to the occiput, and in exceptionally difficult cases even a partial detachment of the muscles from the skull.

In the **lumbar** region the vertebral groove is very deep and narrow, the muscles are not only large and fleshy but reinforced by a very thick and resistant superficial tendon, and the spine is deeply concave backwards. The operation, therefore, is apt to be difficult and tedious, and it is usually necessary to remove the vertebral arches as far out as the articular processes before satisfactory exposure is obtained. No unfavourable consequence need be feared if it is found necessary to remove several of the articular processes.

Function of the spine after laminectomy.—*Very large* numbers of laminæ have been removed without causing any serious weakness or disability of the spine. It is possible that very free retraction of the muscles might lead to damage of their nerve supply—the posterior primary divisions of the spinal nerves. This would perhaps occur most easily in the cervical region, where there is no bony obstacle to free retraction of the muscles. It would produce serious weakness of the extensors of the neck. It is in general prudent to restrict the lateral extent of a cervical laminectomy as much as is consistent with adequate access, not *so much for fear of damage to the muscular nerves* as because the general slenderness and weakness of the cervical vertebræ render their laminæ relatively important in comparison with those of other vertebræ.

The necessary laceration that is inflicted on the muscles during the separation of them from the spines and laminæ seems to have no very harmful effect on their function, but as a matter of general principle it should, of course, be restricted as much as possible, and at the end of the operation the muscles should be carefully sutured in position.

After laminectomies for extensive divisions of posterior nerve-roots in *the cervical region, the necessarily resulting* atony of the extensors of the head and neck is apt to cause a good deal of disability and even deformity.

The membranes and spinal cord.—The spinal **dura mater** [illegible] num, where it is firmly attached [illegible] vertebra, where it ends by blend- [illegible] A fibrous strand, consisting of con-

joined dura and filum terminale, is prolonged downwards through the sacral canal to be attached to the back of the coccyx. The dura is pierced separately by the anterior and posterior roots of each spinal nerve, and sends a sheath into each intervertebral foramen along the conjoined nerve trunk. Its anterior surface is attached by various fibrous bands to the posterior common ligament and the bones of the anterior wall of the spinal canal; its posterior surface has no attachment to the bones.

External to the dura is a thin layer of loose fat which on the posterior surface is but slightly vascular and can be stripped off with the production of very little bleeding. On the anterior surface the fat is usually thicker and contains a considerable plexus of veins; interference with it is apt to cause a good deal of venous oozing.

The spinal theca with the surrounding fat and veins just fills the spinal canal. When the intradural tension is normal the theca does not bulge into a laminectomy opening.

The perithecal fat readily strips off from the posterior surface of the dura, displaying the latter as a cylindrical, glistening membranous tube which is of a pearly grey colour, and shows pulsations of respiratory and cardiac rhythm. Any adhesion of the perithecal fat to the dura, or of either to the bone, is pathological.

When the dura is incised carefully, it is seen to have a laminated fibrous structure. The **arachnoid** is found closely applied to the inner surface of the dura, but in normal conditions shows no obvious attachment to it. The normal unopened arachnoid is kept distended by the cerebro-spinal *fluid*; it is almost completely translucent, but shows a very slight milkiness after it has been incised and has collapsed. Small white calcareous plates a few millimetres across occur commonly in the arachnoid. Two or three may be seen in a length of 3 or 4 inches of the canal. Even when much more numerous, as they sometimes are, they seem to have no pathological significance. The arachnoid, while quite free from visible attachments to the dura, is connected by filmy trabeculæ with the pia mater on the cord. These are not very plainly to be seen except when they have been rendered opaque by chronic inflammation.

The normal **cerebro-spinal fluid** is under just enough tension to make the unopened arachnoid bulge moderately into a dural incision. Its tension, however, varies with the venous pressure, and therefore may become considerable if the patient strains or his respiration is obstructed. The fluid, which is quite colourless and clear, escapes through an arachnoid incision in a continuous stream until the subarachnoid space in the neighbourhood has been drained. The flow then becomes less, but in normal conditions goes on as long as the membranes remain open. As a rule, the flow is about enough to cause an escape from the wound during expiration only. Allowing the fluid to escape freely during an operation does not usually produce any obvious shock effect.

The **spinal cord** is of a creamy white colour with a slight suffusion of pink, and, except at the cervical and lumbar enlargements, is of a strictly cylindrical form. The posterior nerve-roots arise from it a short distance on each side of the middle line and form two practically continuous series of rootlets throughout the length of the cord. Along the line of these rootlets runs on each side the irregular and tortuous posterior spinal vein. The current in these veins is usually upward, and they are apt, therefore, to show engorgement below the site of a spinal compression. The substance of the spinal cord is very distinctly denser and tougher than that of the

brain, and *this* must be borne in mind when such attempts as are permissible are made to estimate the consistence of the exposed cord.

The **ligamentum denticulatum** is attached continuously to the lateral aspect of the cord throughout its length. Laterally, it is fixed to the inner surface of the dura by a series of pointed processes usually about twenty-two in number, the uppermost being attached to the edge of the foramen magnum, and the lowermost being about opposite the 1st lumbar vertebra, where it lies between the 12th dorsal and 1st lumbar nerves. In the antero-posterior direction the ligament is between the origins of the anterior and posterior roots; in the vertical direction its pointed processes are attached to the dura between the openings through which the spinal nerves emerge. When it is necessary to examine the anterior aspect of the cord a process of the ligament should be detached from the dura and gently drawn upon. In this way the cord can, to a limited extent, be displaced laterally and rotated without damage.

GENERAL PHYSIOLOGY AND PATHOLOGY

In attempting to define the more general principles which are of use to the surgeon in dealing with spinal cases, we shall not treat separately the physiological and the pathological facts. The distinction between these two classes tends always to be more or less academic, and in this particular department is apt to confuse rather than to clarify the exposition. For the special purposes of the surgeon, moreover, it is not necessary to enter at all minutely into the structure or functions of the spinal contents, and we shall therefore limit ourselves to such broad and simplified statements as have an immediately practical bearing.

The contents of the spinal canal may, for our present purpose, be discussed in four groups: the *spinal cord*, the *cauda equina*, the *meninges*, and the *cerebro-spinal fluid*.

The spinal cord.—The functions of the spinal cord show a broad division into what may be termed the conductive and the local. The **conductive functions** are those by virtue of which the spinal cord is the great ultimate channel through which pass nervous impulses between the brain on the one hand and the trunk and limbs on the other. When conduction is completely interrupted the patient loses all direct knowledge and all control of the parts supplied from below the lesion. Now, as is well known, the various impulses which pass up and down the cord are not indiscriminately distributed throughout its breadth, but are gathered into definite tracts, the course of which is to a great extent known. Thus, if an interruption of conduction extends only partly across the cord it will produce defects of function having a distribution corresponding with the tracts that are implicated. It is of value, therefore, for the surgeon to have some general knowledge of *the situation in the cord of the paths* followed by impulses coming from the various sources.

Motion.—Impulses concerned with voluntary movement traverse the *crossed pyramidal tract which runs throughout* the cord on the same side as that to which it is distributed. It is a consequence of the situation of the pyramidal tract, that pressure coming to bear on the cord from in front wil [illegible]

[illegible] d

[illegible] of

int [illegible]

changes in passive position, of size and form, of the separateness of two simultaneous contacts, and of the vibrations of a large tuning-fork. These

are conducted in the posterior column of the same side as that on which they originate. They are uncrossed throughout the spinal cord, and evidence of interference with them shows that the posterior part of the cord is affected. (2) Impulses concerned with sensibility to pain, to heat and to cold cross the cord obliquely through the grey matter, taking several segments to cross, and attain the lateral tract, in which they remain throughout the rest of the cord. An isolated loss of these forms of sensibility, then,

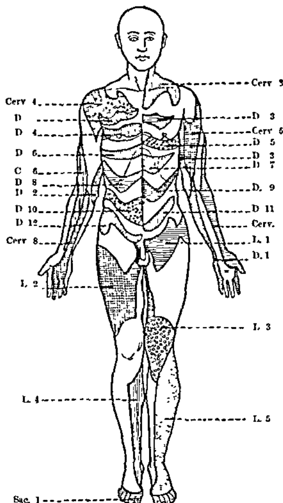


Fig. 746.—Sensory segmental functions of spinal cord. (*Head.*)

may be due to a lesion in the central parts of the cord interrupting conduction in the crossing nerve-fibres, or to a lesion of the opposite lateral

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unilateral lesion they are not usually affected in such a proportion as to

cause tactile anæsthesia. These facts as to the distribution of conducting paths in the cord have their chief importance in relation to incomplete transverse spinal lesions. Of such incomplete lesions, one limited to one half of the cord and interrupting it completely produces the most characteristic picture, the well-known Brown-Séquard type of spinal paralysis. Fully developed cases of this are not common; they show on the same side as the lesion spastic paralysis and loss of spatial sensibility, and on the

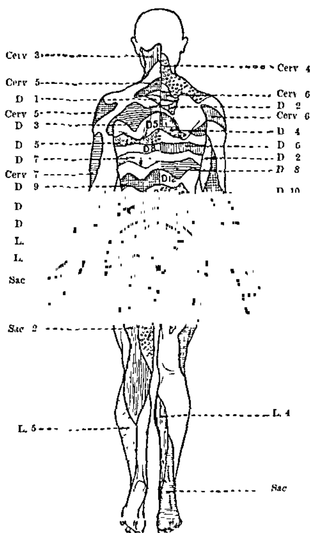


Fig. 747.—Sensory segmental functions of spinal cord. (*Head.*)

opposite side loss of sensibility to heat, cold and pain, while tactile sensibility is not affected.

The **local functions** of the spinal cord are the maintenance of muscular nutrition and tone and the execution of certain *reflexes.*

Phenomena connected with them, while they are usually subsidiary in importance to those connected with *conduction,* are nevertheless far from

being without great practical significance. These functions are of interest to the surgeon in two wholly different ways—(1) by the impairment or abolition of them when the corresponding part of the cord is affected by a destructive lesion, and (2) when by the interruption of conduction their activity displays itself uncontrolled by the patient.

(1) When a part of the cord is affected by a destructive lesion, the muscles which have their nutritional centres in the grey matter of the damaged part are hypotonic, weakened, or paralysed, and waste rapidly; reflexes which should be executed by them are impaired or abolished. These effects when they are produced by damage to parts where function is concentrated, such as the cervical and lumbar enlargements, are readily distinguishable from the effects of interference with conduction, and constitute evidence of the precise situation of the lesion. Thus, for example, a complete destructive lesion limited to the 5th and 6th cervical segments would cause the usual conduction paraplegia, involving lower limbs, trunk and the arm muscles supplied from the 7th segment and below it; the flexors of the forearm, for instance, would not be wasted or atonic. But at the same time the shoulder muscles and the supinator longus would not only be paralysed (like the other arm muscles) but would be flabby and wasted, and the supinator jerk would be lost The effects of the destructive action of an injury on local sensory function are not usually to be distinguished with any similar degree of clearness from the effects of interference with conduction

(2) A transverse lesion of the cord that interrupts conduction in it leaves the distal and undamaged part of the cord

degree of complexity, and to superficial examination may give the fallacious impression that voluntary power is present. Such manifestations are strictly reflex in nature and wholly beyond the patient's control. When well developed they include contractions of the voluntary muscles, contractions of the involuntary musculature of the pelvic viscera, and sweating.

These facts probably indicate the fundamental nature of the phenomenon. In more pronounced instances the movement is a convulsive flexion of the whole limb, accompanied by contraction of the trunk muscles, evacuation of the pelvic viscera, and sweating, and the stimulus need no longer be applied to the foot, but is effective in a much wider area The muscular contractions, however violent, never spread to parts still under voluntary control When they are readily called forth they are a cause of great discomfort and distress to the patient. The visceral reflex activity which the isolated cord is capable of developing is, however, not without value to the patient, as it endows the bladder with the power of emptying itself periodically, and by preventing stagnation of urine diminishes the dangers of urinary infection. The establishment of this automatic action of the bladder is thus undoubtedly the means of prolonging life in patients in whom there is complete functional interruption of the cord The development of these highly active reflex powers by the cord occurs only below a lesion which is causing a virtually complete interruption of conduction, and is in practice usually quite trustworthy evidence that the interruption is complete.

Relation of Spinal Segments and Nerve-Roots to Muscles[1]

Segment	Muscles
C. 1.	*Small flexors of head.* Depressors of hyoid bone.
2.	Sterno-mastoid; Small rotators of head. Complexus. Splenius.
3.	Levator anguli scapulæ. Scaleni. Trapezius.
4.	Diaphragm.
5.	Levator anguli scapulæ. Scaleni. Supraspinatus. Infraspinatus. Rhomboids. Subclavius. Teres minor. Biceps. Brachialis anticus. Deltoid. Supinator longus. Supinator brevis (?). Pectoralis major, clavicular part. Serratus magnus.
6	Subscapularis (? C. 5). Pronators. Teres major. Latissimus dorsi (? C. 8). Serratus magnus (? C. 7). Pectoralis major, sternal part (? C. 8).
7.	Triceps. Extensors of wrist and digits.
8.	Flexors of wrist and digits.
D. 1.	Interossei and small muscles of the hand.
2 to 12.	Intercostals.
7 to 12.	Rectus abdominis. External and internal oblique. Transversalis.
L. 1.	*Quadratus lumborum.*
2.	Cremaster.
3.	Sartorius. Adductors of hip. Ilio-psoas.
4.	Extensor quadriceps cruris. Abductors of hip
5.	Flexors of knee.
S. 1.	Calf muscles.
2.	Glutei. Peronei. Anterior tibial muscles. Intrinsic muscles of foot.
3, 4.	Perineal muscles and sphincter ani.

Table showing the Segments on which the Reflexes depend

Reflex	Segments
Scapulo-humeral reflex	5, 6 C.
Triceps and wrist-jerk	6, 7 C.
Upper abdominal reflex	4, 6, 7 D.
Lower abdominal reflex	8, 9, 10, 11, 12 D.
Cremasteric reflex	1, 2, 3 L.
Knee-jerk	2, 3, 4 L.
Tendo-Achillis jerk	5 L. and 1 S.
Plantar reflex	1, 2 S

The cauda equina.—The cauda equina is the large bundle of nerves that occupies the cavity of the spinal theca below the lower end of the spinal cord. Since the cord ends behind the 1st lumbar vertebral body, the cauda includes all
and therefore contains (1)
limbs, perineum and exter
and urethra; and (2) the principal nerve supply of the bladder and rectum.

The bladder and rectum are to be regarded as possessing a detrusor system of muscles that brings about evacuation, and a sphincter system which closes their outlets. The sphincters are internal and external. Now,

[1] From Horsley's article on Compression Paraplegia in Allbutt and Rolleston's "System of Medicine," 1910.

the cauda equina supplies the detrusor and the external sphincters from the 2nd, 3rd, and 4th sacral roots through the pelvic nerves, whereas the internal sphincters are supplied through the inferior hypogastric nerves from the lower thoracic and 1st lumbar segments. It therefore happens that with a complete lesion of the cauda equina, when all the sacral supply through the pelvic nerves is cut off, the internal sphincters *remain in action* as the hypogastric nerves are undamaged, and retention of urine results. The main sensory supply of the bladder passes through the sacral nerves, but it seems that some of it is contained in the hypogastric nerves, since, with a complete cauda lesion, although the sensibility of the bladder is much reduced, the patient may be able to recognize distension of the bladder or the entry of a catheter into it.

The functions of the cauda equina are like those of any other peripheral nerves. *Interruption* of it therefore causes on the motor side paralysis, atony and wasting of the muscles it supplies, with altered electrical reaction and abolition of reflexes, and on the sensory side anæsthesia affecting all forms of sensibility without such dissociation as may occur with spinal-cord lesions. Injuries of the cauda are frequently asymmetrical and incomplete, but they do not produce conditions of the Brown-Séquard type with paralysis on one side and sensory loss on the other. As in other peripheral nerves, regeneration after division occurs in favourable circumstances in the cauda equina. Moreover, pain is a frequent and distressing symptom.

Meninges and cerebro-spinal fluid.—The overwhelming [illegible] *e contents of the spinal canal tends* [illegible] he important functions which are [illegible]

The **dura mater** is commonly regarded as having its chief function in the mechanical protection of the cord. It is probably much more in its being a *densely impervious insulating envelope that its function lies. It* consists of a very firm laminated fibrous substance which has an endothelial covering not only on its inner but also on its outer surface. When an [illegible]

the gap. If the fluid has been under tension and much has escaped, the new dura will have the form of a cyst opening out of the theca, but, whatever its form, it will always be dense and fibrous and will be differentiated from the surrounding tissues, so that it can be stripped off from them. While this inveterate tendency to the natural sealing off of any opening [illegible]

dura carefully are to prevent the entanglement in it of spinal nerves and to limit the risk of leakage of cerebro-spinal fluid. The latter object can be attained after a laminectomy by close suture of the spinal muscles.

The **cerebro-spinal fluid** is secreted by the choroid plexuses of the brain, and passes out of the roof of the 4th ventricle into the large subarachnoid space of the posterior fossa—the cisterna magna. The greater part of it is directed so as ultimately to reach the surface of the cerebral hemispheres, where it is absorbed into the blood-stream. A small proportion of it, however—perhaps one-fifth of its total volume—passes downward through

the foramen magnum into the spinal subarachnoid space, where by the vessels of the cord it also is absorbed. Normally the fluid remains in hydrostatic continuity with the cisterna magna throughout the whole length of the theca down to the 2nd sacral vertebra. This column of fluid surrounds the cord and cauda equina, and through the unopened arachnoid the spinal nerve-roots can be seen floating in it. Below the lower end of the cord and between the two halves of the cauda equina there is a considerable elongated space filled by the fluid. It is in this collection that the needle is inserted in a lumbar puncture. As the column of fluid is continuous with that within the cranium, it receives and transmits from this the cardiac and respiratory impulses which pass along the whole length of the theca, diminishing in amplitude towards its lower end. These are the pulsations of the theca which are to be seen when the spinal canal is opened It is obvious, then, that when the spinal canal is obstructed as the result of injury, or by a tumour, the downward passage of these impulses is checked and the theca, when exposed below the lesion, will not show pulsation. The spinal cord itself, when exposed, also shows arterial pulsations, but these are very minute and are not arrested by a block in the canal higher up. They are not large enough to be transmitted to the theca. Absence of thecal pulsation indicates, therefore, an obstruction above, and this inference will not be disproved even though, when the dura is incised and the cord exposed, the latter can be seen to pulsate. In such a case, however, some venous engorgement of the cord will usually be present, and will confirm the diagnosis of obstruction

An obstruction of the canal not only arrests the downward transmission of pulsation and causes venous engorgement of the cord below. It also interrupts the downward current of cerebro-spinal fluid, which normally should undergo absorption along the whole length of the cord. There is, therefore, an accumulation of cerebro-spinal fluid above the block: such an [illegible]

ing the canal, and may cause an exploration to be made at too high a level.

It is frequently found at operations for spinal tumours blocking the canal that there is an accumulation of fluid *below* the obstruction as well as above it, and under considerable tension This seems difficult to understand in view of the fact that the thecal cavity below the block is cut off from the access of cerebro-spinal fluid. Two considerations must, however, be taken into account. First, even after the obstruction has become [illegible]

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theca. [illegible]
lates below a spinal tumour shows very definite differences in constitution from normal cerebro-spinal fluid.

The cerebro-spinal fluid, as obtained in a normal lumbar puncture, stands at a pressure (as measured with a water manometer) in the same order as that of the cisterna *magna or the general* intracranial pressure, though naturally somewhat lower. It varies in the same way as the intracranial pressure, and shows a wave of increase with a cough or expiratory effort, or when the jugular veins in the neck are compressed. This fact may be

used to establish the presence or absence of an obstruction in the canal, for if such is present, impulses of increased pressure originating in the skull can no longer be transmitted freely to the lumbar sac and the manometer communicating with it.

Changes in the quality of the cerebro-spinal fluid.—The normal cerebro-spinal fluid is colourless, watery, saline, of low specific gravity (about 1005), and contains a reducing substance and the minutest trace of albumin. Microscopically, it shows a few endothelial cells and an occasional lymphocyte. The chief changes of interest to the surgeon that it may exhibit are (1) blood-staining in cases of intracranial or intraspinal hæmorrhage; (2) in cases of tumour blocking the canal, a yellow colour, which persists after centrifuging, and a considerable amount of albumin; it may even coagulate spontaneously; (3) changes indicating an infection—numerous polymorphonuclear leucocytes, with or without obvious opacity, increased albumin with spontaneous coagulability, and possibly micro-organisms.

INJURIES OF THE VERTEBRÆ AND SPINAL CORD.

There is some similarity between these injuries and those of the skull and brain, in that the injury to the skeleton is not necessarily associated with a lesion of the cord, and that a cord lesion is sometimes present without a demonstrable injury to the skeleton. Broadly speaking, there is usually a coincidence of spinal-cord lesion with certain forms of injury to the skeleton.

Injuries of the Skeleton

These may be divided into those of the column and those of the arches, i.e. transverse, spinous, and articular processes, together with the laminæ.

Injuries of the column.—These are, as a rule, produced by indirect injury, i.e. a bending of the spine, associated in some cases with a compression in the long axis of the column. Instances of this are falls on the back of the neck from a height, and the falling of heavy weights on the back while it is in a stooping position. The position of the lesion depends on the point at which the force is applied; the nature, to a great extent on the situation of the injury.

When the spine is flexed forcibly, the first effect is a compression of the bodies of the vertebræ and of the intervertebral discs, and the upper vertebra tends to be displaced forwards, but is held behind by the articular processes, which prevent any further movement. Should the flexion continue, the lower articular processes of the upper vertebra rise and jump the upper processes of the vertebra below, and a dislocation takes place. These injuries may be divided into those without and those with dislocation.

Injuries of the column without dislocation. Sprains. —This group contains those injuries in which no fracture or displacement can be demonstrated, and in which there are signs of local trauma to the spine, such as tenderness and rigidity, as a

result of a flexion injury to the column. Some of these cases are, no doubt, dislocations which have reduced themselves at once. They are sometimes associated with a lesion of the spinal cord. Very thorough and expert X-ray examination is necessary in these cases to exclude *damage to the bone.*

Compression of an intervertebral disc.—Kocher mentions a case in which this was shown to be the only lesion present in the vertebral column, but the fact that it is so seldom associated with fatal injury to the cord renders the demonstration of its occurrence difficult, and it is possible that many of the sprains are of this nature.

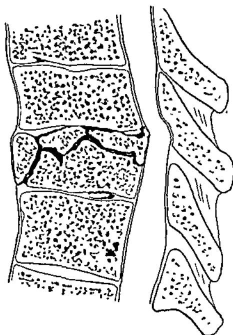


Fig. 748.—Compression fracture. (*After Kocher.*)

Compression fracture of the vertebral body (Fig. 748).—This injury without dislocation is met with in the dorsal and lumbar regions, particularly in the 12th dorsal and the 1st lumbar vertebræ, and in the upper part of the dorsal region about the 4th. It is always due to indirect injury compressing the column in a vertical direction and with some slight flexion. The soft spongy bone is compressed between the upper and lower laminæ of compact bone, and inasmuch as the posterior portion of the body is strengthened by the presence of the pedicles behind, the crushing is more effectual in front than behind. Occasionally one, usually the upper, layer of compact bone is broken up, and fragments are formed which may be displaced backwards into the spinal canal. The articular processes remain intact.

The physical signs are *local tenderness, pain on movement, especially* on flexion, and some angular deformity. The spinous process of the vertebra above is separated from that of the injured bone. There is rarely any marked spinal-cord lesion. Kocher has called attention to the frequency with which a fracture of the sternum opposite the 2nd rib is met with in association with this type of fracture.

Undoubtedly, slight cases of this form of injury are overlooked, and constitute a small portion of the "workmen's-compensation-pain-in-the-back" class

Injuries of the column with dislocation.—In order that a dislocation may take place, either the body of the vertebra must be fractured or the intervertebral disc stretched or torn; the latter is a pure dislocation, the former a fracture-dislocation.

Dislocation.—With rare exceptions in the dorsal region, this occurs only in the cervical region. The dislocation may be either unilateral or bilateral, the former being the commoner. The *unilateral* variety is produced essentially by a bending of the column to one side associated with rotation, so that it has been described as a rotation or abduction dislocation. The lower articular process of the dislocated vertebra is displaced on to the anterior aspect, or merely on to the superior border of the upper process of the vertebra below; there is not, as a rule, any marked change in the position of the articular processes of the opposite side.

The resulting deformity when the dislocation is complete is that the head is turned to the opposite side and approximated to the shoulder of the same side. Some alteration in the line of the spinous and transverse processes may be felt, but the most marked local physical sign is the displacement of the bodies of the vertebræ as felt by the finger in the pharynx. The finger can reach to the lower border of the 4th cervical vertebra. There may be pain in the distribution of the nerves pressed upon by the dislocated articular process.

When the dislocation is incomplete (subluxation), i.e. when the lower articular process of the upper vertebra is poised on the upper articular process of the lower bone, the head is still rotated to the opposite side but flexed laterally to the shoulder of the opposite side, i.e the same side as the one to which it is rotated.

Bilateral dislocation.—This is almost always brought about by flexion of the spine, and is invariably associated with a tearing of the intervertebral disc, and frequently, but not always, with injury to the spinal cord. It is practically limited to the cervical region. The head is held stiffly and in a forward position.

Fracture-dislocation (Fig. 749).—This is merely a further stage of a compression fracture of the body. The upper fragment slips forward, and may come to lie on the anterior surface of the lower fragment. The articular processes are either dislocated or fractured. The body is not always fractured as in a compression injury, but may be broken obliquely, the line of fracture running downwards and forwards; this latter form may involve more than one vertebra, so that the inferior posterior edge of the upper vertebra may be left attached to the lower fragment. The displacement is always greater in this variety, and consequently the injury to the spinal cord is more marked, the upper and posterior edge of the lower fragment cutting into it.

The compression fracture-dislocation is most common in the lower dorsal region, which is also, as would be expected, the commonest position of the pure compression fracture; while the oblique fracture with dislocation occurs in the upper dorsal, especially about the 4th dorsal.

Injuries of the processes. Laminæ.—These are usually broken by direct violence, and the local physical signs of trauma will be evident. If the lamina is driven in, the spinal cord will be injured, and when this is the case operation is usually satisfactory.

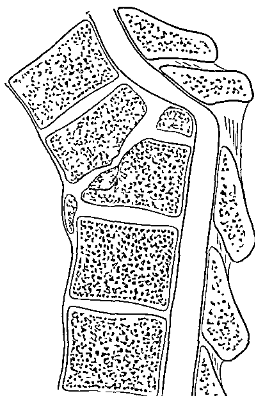


Fig. 749.—Fracture-dislocation. (*After Kocher.*)

Spinous processes.—These may be broken by direct violence or, rarely, by muscular action. Signs of local trauma are present, with perhaps crepitus when the spine is moved.

Transverse processes.—A few cases of fracture of these processes in the lumbar region have been brought to light by X-rays, and the possibility of this injury should be considered in cases of pain in the back following trauma. The fragment has in some cases been removed with relief of symptoms. Rhys has suggested that some of these radiographic appearances indicate developmental anomalies and not fractures.

Injuries involving the atlas and axis.—Dislocation of the occiput on the atlas is very rare. The displacement is usually backwards, and is always fatal.

Dislocation of the atlas on the axis.—This usually occurs forwards, and may be associated with a fracture of the odontoid process. When the process is intact the transverse and odonto-occipital ligaments are usually broken, and the odontoid process penetrates the cord. If the process is fractured it is carried forwards with the atlas and the risk of cord injury is less. Fracture of the

lateral mass of the atlas is sometimes associated with this injury. As a rule these injuries are immediately fatal, but a number have been recorded in which cord symptoms were absent at first and only occurred later as a result of further movement or attempts at replacement.

In any case in which this injury is suspected the naso-pharynx should be carefully examined, and, if possible, a radiograph taken through the open mouth.

Attempts at replacement should be made, preferably under anæsthesia, if cord symptoms are present; otherwise the head should be fixed completely by plaster at once, and maintained fixed for a year or more

Atlo-axoid subluxation or **rotation-subluxation** is a unilateral and minor degree of dislocation. The patient, often a child, presents himself with the neck usually bent towards the sound side and the face looking in the same direction. Local pain may be absent or present. Cord symptoms are absent. Many such subluxations reduce themselves with a snap; in other cases careful reduction under anæsthesia is necessary.

Spinal-Cord Injuries

Mechanism and nature.—The pathology of spinal injuries is apt to be confused by the use of terms such as concussion and compression, which suggest that there is a close analogy between the mechanisms of injury to the spinal cord and those of injury to the brain. There is in fact no such close relation, and these terms, which in cerebral pathology are used with a precise and highly technical meaning, are applicable to spinal pathology only in their current and general sense, concussion signifying a sudden and forcible jolt or jar, and compression a more or less gradual squeezing.

The spinal cord is more strongly protected by the spine than is the brain by the skull, so that it is extreme violence only, and of such a grade as is capable of fracturing or dislocating the spinal bones, that can cause serious injury of the cord. It is not, however, true to say that only with fracture or dislocation can spinal injury be produced. Stab wounds of the neck or back are capable of penetrating between laminæ and wounding the cord. High-velocity projectiles passing through the body in the neighbourhood of the spine may cause definite spinal symptoms by the transmitted concussion, though it is probably rare for actual structural damage to be inflicted on the cord without some injury of the spinal column. No very precise classification of injuries of the cord can be made, but it is convenient to make a rough grouping of the various representative lesions in the order of their severity.

1. The mildest grade of spinal injury is seen where the neck is forcibly extended or flexed without dislocation or fracture. It is probable that the effect on the cord is produced by stretching over and pressure against the walls of the forcibly arched spinal canal. The accident may occur during diving or at football. The neck is forcibly extended or flexed and an immediate though very short-lived spinal quadriplegia ensues. It passes off usually within a few minutes; for a few days or weeks there may be tingling in the limbs with or without some weakness. The neck is apt to be stiff and sore for some little time, but there is no evidence of bone injury.

2. A severer grade of injury of a similar type is sometimes referred to as concussion of the spine. The passage of a bullet or the impact of a shell fragment near the spine, a violent fall on the back, or the proximity of an explosion—all without causing fracture of spinal bones—may be the cause of the injury. There is paraplegia of immediate onset and lasting a few hours, a few days, or even several weeks, but ending in recovery. It is to be supposed that in the milder cases no destructive change in the cord has been produced, though in the severe cases there is a gradual merging into the next class, and delayed recovery suggests that there has been at any rate some organic damage.

3. Definite local organic damage of the cord is present. The terms contusion and laceration are sometimes used for these conditions in a quasi-technical sense; they have no special applicability, and the first of them, since it embodies the idea of extravasation of blood as an essential feature, is misleading Gunshot wounds implicating the vertebræ, dislocations and fractures from direct violence with displacement and infraction of laminæ, are the principal causes.

Whatever the nature of the violence, the changes produced in the cord are very uniform in character. Hæmorrhage is inconspicuous and usually confined to small points of ecchymosis; irregular swelling of axis-cylinders and the breaking-up of myelin sheaths are generally to be seen; the most characteristic change is the formation of necrotic areas and definite cavities containing broken-down nerve tissue. The injured region tends in the early stages to be swollen and yellowish in colour. It is œdematous, and the œdema extends above and below it for a segment or two. In the later stages the dura is often found to be adherent to the cord and to the bone, and the cord much shrunken. It is probable that the interruption of conduction brought about by the actual destructive damage is increased by the pressure of the œdematous swelling and the tension of the contents of the necrotic cavities, and that these factors tend to increase the subsequent secondary fibrosis. There can be no doubt

that the destructive effects of these lesions is greatly increased by the presence of infective processes.

4. **Complete transection of the cord.**—This is a common result of gunshot wounds and fracture-dislocations. The divided ends of the cord show changes like those just described. Each end tends to become enlarged, rounded off, and firmly fixed to the dura. Complete and irreparable conductive interruption is often present without actual physical section of the cord, so that the determination of the presence of a definite solution of continuity is unimportant.

Modes of interference with function: spinal cord.—There are three primary ways in which an injury affects the functions of the cord; these may be referred to as spinal shock, compression, and destruction. In addition to these, secondary factors may come into action, namely hæmorrhage, vascular changes causing softening, and infective processes; and finally there is a small group of sequelæ or remote effects of injury.

Spinal shock.—This is the name given to the extensive loss of function *at and below the seat of the lesion* that comes on in the moment of a severe spinal injury, but tends to pass off within a few weeks The characteristic features of the loss of function are that it does not extend above the site of the injury but does extend far down the cord below. Where it obtains, conduction and reflex activity are abolished. With a severe lesion high up in the dorsal region all reflexes below may be lost except those depending on the lowest segments, such as the anal reflex and that of the bulbo-cavernosus. If any limb reflex remains it will be a downward movement of the big toe in response to plantar stimulation. In from seven to ten days the condition begins to pass off, and if there has been loss of all the limb reflexes the downward movement of the big toe appears first. This soon changes to an upward movement, and is accompanied by flexion of the limb. In about three weeks the knee- and ankle-jerks may appear, and about the same time the beginnings of automatic evacuation of the bladder and rectum. On account of the occurrence of spinal shock, no operation for a spinal injury should be undertaken during at least the first three weeks, unless there is some very special indication for it, such as the escape of cerebro-spinal fluid from a wound.

Compression.—All local injuries of the cord tend to be accompanied by conditions which cause pressure to be exerted on the damaged part. Of these, œdema and reactionary swelling are the most constant and important. In addition, there may be the pressure of displaced bones or bone fragments, foreign bodies, and hæmorrhage. At later periods inflammatory conditions and abscesses and secondary fibrosis and contraction may also exert injurious

pressure. Finally, obstruction of the canal may lead to accumulation of cerebro-spinal fluid at a sufficient pressure, when acting over a long length of the cord, to cause an indefinite interference with function which will be *characteristically distributed above the* lesion.

If an interference with function is due to pressure alone, it may be just as profound as if it were due to destruction, and it may endure for an indefinite period—certainly many months—and yet be capable of complete recovery if the pressure is wholly relieved. There can be no doubt, however, that loss of function due to pressure does become permanent and irreparable if the pressure persists long enough. Permanent damage by pressure seems to occur more readily in the grey matter than in the conducting tracts. It is not possible to set a period beyond which purely pressure effects become irreparable. We have seen a paraplegia from a spinal tumour that had been total and absolute for three months begin to clear up within a few days of the removal of the tumour, and finally pass off without leaving a single trace in motor, sensory, or reflex activity. We have also, of course, seen cases in which an absolute paraplegia of much longer duration has cleared with a perfectly satisfactory functional result, though some of the reflexes remained abnormal. It is probably safe to say that there need be no anxiety as to pressure effects becoming permanent within two months of an injury, so that the surgeon need have no hesitation in waiting for spinal shock to pass off completely before deciding whether or not operation should be advised in a given case.

Compression effects constitute the chief if not the only factor in the pathological condition following a spinal injury which the surgeon can control by operative treatment. It is on the importance of this factor in a given case, then, that the prospects of useful surgical interference depend. In cases of spinal injury, whether it be from professional optimism or the natural desire to present to the patient the most hopeful aspect of his terrible situation, there can be no doubt that the surgeon tends to overestimate the extent of the possible influence of pressure in the individual case, and to hope too much from the relief of it. There is no means of determining whether a given loss of function is due to pressure or to destruction, and the question must be determined as far as may be by collateral evidence. Theoretically, of course, a total interruption of conduction might be chiefly or even wholly due to compression. Practically, in cases of injury, it is found that the relievable element in any very extensive loss of function is usually extremely small. The more nearly, therefore, the symptoms approximate to those of a total interruption of conduction after the spinal shock has passed off, the less likely is

direct operative treatment of the spinal lesion to be of any real value. Conversely, the cases of injury in which most is to be expected from operative treatment are those with obviously incomplete lesions which have shown some power of spontaneous improvement.

Destruction of the cord substance.—In the spinal cord, as in the brain, there is no regeneration of any nervous tissue that has been destroyed. Any defect of function, then, that is certainly due to destruction is certainly irreparable, and there is no evidence to justify an operation undertaken for suture or grafting of a cord known to be divided. Owing to the close concentration of function in the spinal cord, symptoms directly dependent on destruction of the nervous substance are much more conspicuous in cases of spinal injury than in cases of head injury. As already mentioned, it is not known how longstanding and how severe must be a compression for the effect on the nervous tissues involved to become destructive.

Secondary modes of interference with function.—*Hæmorrhage* may produce ingravescent impairment of function in spinal injuries. In sufficient bulk to cause such effects it is not a common occurrence. Large extrathecal and large intrathecal hæmorrhages are found occasionally, and have been supposed capable of causing irritative phenomena in the spinal roots, especially in those of the cauda equina, towards which intrathecal hæmorrhages tend to gravitate. Intramedullary hæmorrhage spreading extensively in the cord substance upwards and downwards from the primary lesion is by comparison not uncommon. When it is not masked by spinal shock it tends to produce ingravescent symptoms progressing for some days after the injury. These are naturally most characteristic when they can be referred to the grey matter (atony and atrophy of muscles, abolition of local reflexes) and to the tracts crossing through it (defective sensibility to pain, heat, and cold). Pressure on the surrounding white tracts tends also to cause interruption of conduction through them. Intramedullary hæmorrhage does not usually call for operative exposure and incision of the cord to allow of evacuation. Good spontaneous improvement and even complete recovery are common in favourable cases.

Secondary softening of the cord possibly due to thrombosis of medullary vessels is an occasional cause of delayed symptoms, especially in elderly patients. It is a contra-indication to operation, the disturbances from which are likely to aggravate it.

Infective processes are to be considered as local and distant. *Local infections* in the injured part, such as are very common in cases of gunshot wound, add to the effect of all the injurious processes we have described, and may lead to the very grave complication of a spreading meningitis. They frequently, however, remain latent or

subside, leaving encapsuled foreign bodies or abscesses which are potential causes of intercurrent meningitis for an indefinite period. The possibility of precipitating an outburst of meningitis must always be considered when a late operation for the removal of a foreign body is contemplated. *Distant infections* are extremely important in cases of spinal injury on account of their power of depressing the function of the spinal cord through the general toxæmia. An intercurrent attack of pyelonephritis, cystitis, bronchitis, or pneumonia may in a few hours abolish the improvement in spinal function that has been laboriously hoarded through months of careful nursing, and such relapses are often but very slowly recovered from. The guarding of spinal patients from casual infections such as the common cold is therefore extremely important.

Remote effects of spinal injury.—*It is intended briefly to* discuss here certain mechanisms by which function is interfered with indirectly and through the agency of a more or less distinct pathological process. Thus, although the injury may be ultimately responsible for the actual appearance of symptoms, there tends to be a certain disproportion between it and the seriousness of the fully developed clinical state.

1. *Aggravation, by injury, of pre-existing spinal disease.*—There is very little doubt that chronic diseases of the spinal cord are apt to advance rapidly after spinal injuries. Such diseases as tabes and disseminated sclerosis may have been running a practically latent course up to the time of the accident, and then progress in a way that gives them the appearance of having been directly caused by the injury. *In such cases, on the one hand the symptoms of disease may* at first be mistaken for direct results of injury, and on the other hand and at a later period it may fail to be recognized that the accident has at any rate some of the responsibility for the patient's actual condition.

2. *Chronic meningitis of traumatic origin (meningitis serosa circumscripta).*—This is a localized arachnoiditis in which the arachnoid membrane and its trabeculæ are much thickened, so that the subarachnoid space *for perhaps a distance of several inches is occupied* by a series of cyst-like cavities containing clear fluid. This condition is capable of exercising on the spinal cord a degree of pressure sufficient to interrupt conduction; it also constitutes an obstruction of the spinal canal above which the accumulation of cerebro-spinal fluid may exercise enough pressure to produce, as it were, a fringe of much slighter and less definite symptoms above those of the local lesion. Meningitis circumscripta has been ascribed to many causes, including infection and injury. *In our experience the clinical evidence points* very strongly towards injury as the usual cause. The injury is, as a

rule, long antecedent to the appearance of the symptoms, and consists in a heavy fall on the back without, however, any evidence of bone injury. It is probable that a local contusion of the cord and meninges is the mechanism by which the condition is set up.

In all the severe localized injuries of the cord, conditions resembling meningitis circumscripta are apt to occur. In the clinical picture, however, they are overshadowed by the much more serious accompanying damage to the cord. In cases of spinal injury which have made good progress towards recovery but have disappointed the hopes of the surgeon by not attaining it, it should be remembered that the symptoms are possibly being kept up by some such meningeal sequel.

Modes of interference with function: cauda equina.—In the presence of injury the elements of the cauda equina behave in all respects as do other peripheral nerves. They are liable to temporary interruption of function by violent shocks or concussions, as by the passage of a rifle bullet near them or by a sharp blow from displaced bone at the moment of fracture. They suffer from pressure through the agency of displaced bone, foreign bodies, inflammatory collections, and cicatricial bands and adhesions. They are exposed to the extension into them of infective processes from septic wounds implicating the theca. Finally, they may be actually divided by a stab or gunshot wound, or by displaced bone in a fracture.

Disturbance of function is not wholly in the direction of paralysis, as it is with the damage at the seat of injury in the spinal cord. Pain is a frequent and grave complication of cauda-equina injuries.

Regeneration undoubtedly occurs in cauda-equina injuries. As with other peripheral nerves, it occurs more readily when neuron interruption has been due to pressure without rupture of the nerve sheath than when there has been actual section of the nerve itself.

Operative suture of divided strands of the cauda is very rarely possible owing to the difficulty of bringing the ends together, even if they could be identified. As with cord injuries, the main object of the surgeon is the relief of undivided structures from pressure. It is, perhaps, less often necessary to advise operation in cases of cauda-equina injuries than in cases of spinal-cord injuries because of the strong tendency to spontaneous recovery. On the other hand, pain is often in itself an indication for operation The pain of mere pressure on undivided nerves is much less intractable than is pain arising from nerves which have been divided and exposed to infection.

Symptoms of injury of the spinal cord and cauda equina.—In civil practice serious injury is almost always the accompaniment of dislocation or fracture of the spine. Stab wounds are

seen occasionally. The injuries of warfare are, of course, mostly gunshot wounds by bullet or shell fragment. Such a case, while having the serious aggravations of the wound itself and the conditions in which it has been inflicted, does not usually have the disadvantage of actual discontinuity of the spinal column.

The ordinary fracture or dislocation of the spine is the result of extreme violence, and is therefore usually accompanied by severe immediate shock. *The serious damage to the cord is inflicted at the* moment of the accident, but is probably often added to by the zeal of those whose help is first available. The best thing to do for the patient in the first instance, until a proper method of moving has *been arranged, is to lay him flat on the ground and cover him as* warmly as possible. It will already be obvious from gross paralysis or anæsthesia whether a serious cord injury has been sustained.

When the patient has been given an injection of morphia and moved, with proper precautions, to bed, an adequate preliminary examination should be made. There will then be usually manifest: (*a*) evidences of general shock; (*b*) evidences of the injury to the spinal column; and (*c*) evidence of the cord or cauda-equina injury.

Paralysis, anæsthesia, and abolition of reflexes will be present, and indicate the level of the lesion. The nearer the injury is to the lower end of the cord, the more likely is the absence of reflexes below it to be absolute. With fractures as high as the upper dorsal region the anal and bulbo-cavernosus reflexes are likely to be present even thus early, and there may be a downward movement of the big toe when the sole is stimulated. With the less severe injuries, some power and sensibility may be present below the lesion from the first. The general shock usually makes any very precise diagnosis impossible in the first few hours, and the surgeon should content himself with establishing the general features of the cord injury, with satisfying *himself as to the presence or absence of any injury other than that of* the spine, and with attending to the state of the bladder.

It is desirable to have a lateral X-ray picture taken of the spine as soon as possible.

By the end of twenty-four hours from the accident a fairly thorough examination of the neurological condition should be possible, and a record should be made as a basis for future comparison. If the surgeon has a clear idea as to what observations he wants to make, and a systematic way *of setting about them, a satisfactory examination* can be got through fairly quickly and without much fatigue to the patient.

During the first three or four weeks the clinical picture is apt to change in a confusing way *in severe cases because of the resumption* of reflex activity in the cord below the lesion through the passing off

of spinal shock, and in moderate and mild cases through the passing off of concussion effects of slight intensity. In cases of the first type there will be no essential change in the upper limits of the voluntary paralysis and anæsthesia; in cases of the second type actual modifications in the paralysis and anæsthesia will occur, usually more readily in the anæsthesia, and not necessarily at its upper limit only. For example, in cervical injuries a return of sensibility may first be made out in the areas supplied by the sacral segments because the conducting tracts from these are more deeply placed in the cord than those from the lumbar and dorsal regions.

There is no limit to the variety of combinations of symptoms that may be produced by lesions at different levels and of different intensities. Anything approaching a thorough enumeration of such combinations is, of course, impossible, and we shall only touch very briefly on some of the more marked clinical pictures.

Injury about the 4th cervical segment, if severe, is usually fatal in a short time through paralysis of all the chief respiratory muscles. If the lesion is moderate, and the innervation of the diaphragm survives, there is a more or less complete quadriplegia, and complex involuntary reflex movements ultimately appear in all four limbs.

Injury of [illegible] ve a flaccid paralysis wit [illegible] he injured part of the e [illegible] will share in the interference of function due to affection of the conducting tracts.

Injury of the cervical enlargement in its lower part will cause flaccid paralysis with wasting of the small muscles of the hand and flexors of the wrist and fingers; paraplegia with involvement of the intercostal and abdominal muscles; narrowing of the palpebral fissure and of the pupil, with loss of dilatation on shading, through involvement of the sympathetic supply to the orbit owing to implication in the first dorsal segment. Respiration is carried on by the diaphragm with the sterno-mastoid and scaleni.

Injury in the mid-dorsal region gives a typical picture of a loss of function from interruption of conduction only. Ordinary respiration is satisfactorily carried on by the intercostals and diaphragm, but forced expiration and coughing are greatly weakened by the paralysis of the abdominal muscles.

Injury of the lumbar enlargement and conus produces effects by interfering with conduction in the tracts and interfering with the functions of the grey matter. The more predominant the latter factor the more will the symptoms resemble those of cauda-equina injury. In cases of extensive injury the diagnosis may be doubtful, but can usually be determined by the survival of some reflex activity

possible here to discuss the subject in detail. Expert nurses should be able to maintain the nutrition of endangered parts by cleanliness and massage, and by the skilful distribution of the patient's weight, and be able to move him on his side and keep him there in reasonable comfort for a certain proportion of every day. Incidentally, it may be mentioned here that patients with fractured spines are often exposed to unnecessary suffering through being kept lying perfectly flat when a certain amount of elevation of the head and shoulders brings the spine much nearer its natural shape. The sloughing bedsore is a formidable complication, and is often associated with serious toxæmia, which is apt to affect the spinal cord very unfavourably. Deep sloughing with suppuration and inadequate drainage may render surgical interference necessary. The bedsore in the form of a sinus is usually seen in the later stages It is apt to occur over the great trochanter or ischial tuberosity, and seems to originate in the bursæ there. A small sinus discharging pus leads into a thick-walled, foul cavity containing sloughs and mucoid-looking pus. These conditions always call for surgical treatment. A small inert bedsore with very thick and callous edges can often be got to heal readily if the margin of it is completely cut away.

Another most important part of the treatment—and this also is very much in the nurse's hands—is the prevention of deformity in the paralysed parts. Foot-drop and contracture of the limbs in flexion and adduction are the two principal deformities to be avoided. From the first the feet should be supported and protected from the pressure of the bedclothes. Flexor spasms are diminished by avoiding any cause of stimulation and any visceral disturbance that acts in the same way. A slightly flexed position of the limbs has a similar beneficial effect

There is a tendency to keep patients with spinal injuries too long inert and recumbent in bed. Consolidation of the fracture may be expected to be well advanced in about two months, and from that time the patient should be gradually propped up in bed and taught to tolerate the sitting posture. By the end of three months in a favourable case he should be fit to be got out of bed into a wheeled chair. A certain amount of enterprise in this direction reacts favourably on the patient's general and local condition.

Operative treatment. (A) **Of the primary lesion.**—Immediate operation can only be rendered necessary by the presence of an open wound, and the surgeon will have to decide whether the prospects of preventing or diminishing infection justify intervention. The presence of foreign bodies and the leakage of cerebro-spinal fluid would be reasons in favour of operation. Once active infection of the wound has begun, operation, unless to establish drainage, is out

of the question until healing is complete. Operation for the treatment of the actual cord injury is never necessary as an immediate procedure, and when indicated should be delayed until after spinal shock has passed off. From three to eight weeks after the injury is perhaps the period most suitable. In two classes of cases operation is obviously contra-indicated, namely, cases in which recovery has begun early and is progressing continuously at a satisfactory rate, and cases in which, although spinal shock has passed off, there is evidence of complete conductive interruption (absence of voluntary power and of sensibility, presence of reflex flexor spasms and automatic micturition, X-ray evidence of gross displacement of the vertebræ at the fracture). The most hopeful cases for operative treatment are those in which recovery has begun early and at first progressed well, but has become very slow or has ceased altogether. No operation should be done during the course of an intercurrent infection or an exacerbation of urinary sepsis. At very late periods after the injury, residual symptoms or a slow reappearance of symptoms may suggest the existence of meningitis circumscripta and call for operation. Since suture of divided roots is usually impossible, the indications in cauda-equina cases are much the same as those for cord injuries. In addition, operation may be indicated on account of pain

Laminectomy for spinal injury—The patient should be in the lateral position, except when it is desired to expose the upper cervical cord. The prone position is then the best, with the patient's forehead supported on a head-rest and the neck flexed; intratracheal administration of the anæsthetic is then also an advantage. A vertical median incision is the best; before making the incision it is well to mark by a transverse scratch on the skin the situation of one of the spines that has been definitely identified. The muscles should be turned back from the spines and laminæ without avoidable laceration. There is usually a good deal of bleeding at this stage, which is to be controlled by temporary packing with wet gauze. Any conspicuous spouting vessel may be picked up, but it is not worth while spending much time in the use of artery forceps, as packing, hot irrigation, and getting the muscles well held back by mechanical retractors are always effective. The spines and laminæ are removed with forceps, the canal being first opened above and below the lesion, and then the bones over the damaged part carefully nibbled away. The so-called osteoplastic methods of laminectomy should never be used, as they complicate the operation seriously without being in any way necessary for a good functional result. Great care must be used in removing the bone from over the damaged region, as the parts are usually displaced and their relations much confused by scarring, and the canal is often not only narrowed but tortuous as well. When the

dura has been freed from the bones, and any prominence or angularity of the latter removed as far as may be, the theca is opened above the lesion. In the absence of infection of the wound this should always be done, not only in order to inspect the cord and ascertain if there is any condition such as a cyst or adhesions that can be benefited, but also to get rid of the block to the downward passage of cerebro-spinal fluid that the injury has usually set up. If a foreign body is known to be present it should be removed, if it can be found by a not unreasonably prolonged search. The possibility of latent infections accompanying foreign bodies should be borne in mind, however long a time may have elapsed since the injury; in such a case the surgeon must be prepared for a recrudescence of sepsis in the form of a spreading meningitis.

In operations for cauda-equina injuries there is no special feature that need be referred to, except that the surgeon should look carefully for bands of adhesion, that may be constricting the nerves, and that he should take no risk of inflicting further damage in order to attempt any elaborate plastic procedure.

In operations for spinal injury the theca should not usually be stitched up. This is apt to risk constriction of the damaged cord or cauda and the re-establishment of obstruction to the cerebro-spinal fluid. Careful suturing of the muscles in layers will ensure the prevention of leakage of fluid. It is also a valuable measure against a hæmatoma and against gaping of the wound.

It is not usually necessary to keep the patient in bed for more than a month after the operation, unless there is some special reason apart from the operative interference. The subsequent use of a spinal jacket is not rendered necessary by the operation as such.

Complications.—Relapses of urinary or respiratory infections are not uncommon after the operation. They are always to be taken into account in making the decision to operate. Hæmatoma, leakage of cerebro-spinal fluid, and gaping of the wound can be avoided by careful suture of the muscles. They are to be treated by re-suture of the wound at once under an anæsthetic. A relapse of spinal meningitis following on the disturbance of a latent focus of an old infection causes fever, severe pains in the back and lower limbs, and distension of the wound with cerebro-spinal fluid. Such a condition is serious, but not necessarily fatal. It is to be met by sitting the patient bolt upright in bed, allowing free escape of cerebro-spinal fluid from the wound, and frequent dressing.

(B) **Of complications and sequelæ**.—The use of cystotomy for very obstinate cystitis and the surgical treatment sometimes necessary for bedsores have already been referred to.

If the posture of the feet has been neglected and *foot-drop* has

become fixed, tenotomy of the tendo Achillis may be necessary if the deformity is preventing a recovering patient from walking.

The treatment of the consequences *of hypertonus in the muscles* that are, or have been, weak or paralysed forms an important branch of the surgery of spinal injuries. It is, of course, of the utmost importance *in the first place to prevent flexor spasm of the lower limbs* from developing into a fixed deformity in flexion. In the matter of controlling flexion of the limbs without causing damage to the skin from pressure, the ingenuity and patience of the nurse are of the utmost importance. If flexion is allowed to occur uncontrolled, fixed flexion of the knee and hip is likely to develop. Even then much can be done by a skilled masseur to get rid of the deformity. Tenotomies, chiefly of the hamstrings, may be necessary. In bad cases their value is much reduced by the contraction of ligamentous structures at the back of the joint.

Spasm of the muscles is sometimes disproportionate to the amount of weakness, so that a patient may have recovered enough power to stand, or even walk, but is prevented from using it by the onset of intense spasm the moment he puts his feet to the ground and tries to walk. In cases such as this, operative treatment for the relief of spasm is called for. Three methods are available: (*a*) Tenotomy or transplantation of spastic muscles; the former method is applicable chiefly to the tendo Achillis and hamstrings, the latter chiefly to the hamstrings, one or more of which may be divided and inserted into the quadriceps tendon. (*b*) Interruption of the nerve supply of a group of spastic muscles; this is practically available only in the case of the adductors of the thigh, for the obturator nerve may be thrown out of action without producing any other noticeable disability than that which is desired. The easiest way to do this operation is to open the abdominal cavity, find the nerve in its subperitoneal course to the obturator canal, and crush it with artery forceps. Both nerves can be dealt with through the one incision. This small operation is of considerable practical value, since cases are not uncommon in which adduction spasm alone is keeping the patient from walking. (*c*) Reduction of muscular tone throughout the limb by dividing posterior roots within the spinal canal (Förster's operation). Cases are not common in which the excess of spasticity over weakness is pronounced enough to justify this formidable operation in the hope of restoring the power to walk. It is difficult to produce enough reduction of tonus to be useful without at the same time causing so much ataxy as to be a bad exchange even for severe spasm. Nevertheless, there are a few cases in which the operation is thoroughly worth trying. The lower end of the cord should be exposed by a free removal of the 10th, 11th, and 12th dorsal and 1st lumbar laminæ and

free incision of the theca. It is scarcely ever possible to identify each posterior root with precision and to separate it from its fellows, but this is not necessary, as the object of the operation is to produce a general and evenly distributed reduction in the number of afferent fibres entering the cord. The 12th dorsal nerve can be identified by its place of exit, and the identification can be confirmed by the relations of the lower end of the ligamentum denticulatum. This ligament ends below in a fork, the outer limb of which is the last denticulation and is attached to the dura between the exits of the 12th dorsal and 1st lumbar nerves; the inner limb is the lower end of the attachment of the ligament to the cord and is prolonged on to the conus. The outermost nerve lying on the fork is the 1st lumbar. Alternate bundles of the rootlets of posterior nerves are now divided from above down on each side, beginning with the 1st lumbar. It is generally regarded as necessary to reduce the total number of posterior root-fibres by something in the neighbourhood of two-thirds in order to produce sufficient reduction in muscular tone to be useful. In cauda-equina lesions, especially those due to gunshot wounds, pain is a frequent and very serious complication. It may come on and persist from the moment of the injury, or gradually develop in the subsequent weeks. Its distribution depends on the nerve-roots that are injured, so that it may be felt in the viscera as well as in the limbs. It may be associated with complete or partial anæsthesia of the part, and in the latter case is apt to be aggravated by stimulation of the part in which it is felt.

The treatment of pain in cauda-equina injuries is dealt with in connexion with the treatment of other varieties of pain.

Treatment during the later stages.—When it is established that interruption of conduction in the spinal cord is complete and permanent, the sooner the patient is settled into such an approximation to normal life as is possible for him the better. Three months is time enough for the consolidation of a spinal fracture, and at about that time the patient should be got into a wheeled chair and encouraged to be enterprising in the use of it. With automatic micturition and defæcation well established, and cystitis well under control, the patient may be expected to live for many years a life that many have found to be quite tolerable. The majority of patients with complete transverse lesions die, however, within a few years, and almost always from infection of the urinary tract. These infections, even when micturition is automatic and every care is taken of the bladder, are subject to acute exacerbations, accompanied by high fever and toxæmia Any such attack, without showing special differences from those that have preceded it, may be fatal, and each attack is more dangerous than the one before it, since there is a progressive deterioration of

the kidneys. When the lesion is incomplete, and everything possible has been done to encourage recovery of it, the problem remaining is to make the best use of such function as survives. The result depends very much on the resolution and mental vigour of the patient. It is to be remembered that slow improvement after a spinal injury may go on for an indefinite period What can be done to aid defective function is a matter to be studied specially for each case The ability to stand and to walk, even though only for a few steps at a time, is an immense boon to a patient otherwise tied to a chair. By the use of orthopædic apparatus it can sometimes be obtained for a patient with little or no power below the hips. Any form of activity and independence, however small, reacts favourably on the patient's physical and mental condition.

Treatment of dislocations.—Reduction should be attempted in all cases as soon as possible after the injury, since it becomes increasingly difficult as time goes on. It may be tried up to about eight weeks after the accident.

In the *unilateral* form, if complete, an anæsthetic should be given; the spine should then be pulled upon by means of the head and the upper cervical vertebræ; if the upper fragment is now rotated backwards on the dislocated side, the bones may slip into place. If this fails, an attempt may be made by increasing the deformity by lateral flexion to the opposite side, followed by rotation as before.

In *subluxation* the bones may slip backwards spontaneously, or traction without an anæsthetic may be sufficient.

In the *bilateral* form great care must be taken not to increase the deformity, since this would be likely to cause or to augment pressure on the cord. Traction with pressure forwards on the lower vertebra is probably the safest method, although some surgeons advise that the condition be treated as two cases of unilateral dislocation, one side being reduced by abduction and rotation, and, when this is in place, the other side similarly treated. This latter method is not without risk to the cord.

TUBERCULOSIS OF THE SPINE

Tuberculous osteitis of a vertebra usually originates in the body of the bone, either in the para-epiphysial region or beneath the periosteum. Central osteitis with angular curvature is commoner in children; in adults a subperiosteal localization is more frequent. The disease may arise in the laminæ or close to the epiphysis of the spinous process. It is sometimes limited to one vertebra, but commonly shows signs of spread to the adjacent bodies. The intervertebral discs are, as a rule, extensively destroyed (Figs. 750, 751),

and this selective destruction, on superficial examination, sometimes gives the appearance of a primary focus in the disc.

The process is a rarefying osteitis leading to softening and caseation with little or no sclerosis; occasionally, especially in old people, a dry caries is present. The superimposed weight of the trunk brings about a collapse of the diseased vertebral body, and a flexion deformity is produced. If one body is affected the angle will be sharp, while if several have collapsed the deformity is still angular, but the apex of the angle will be blunt. When several intervertebral

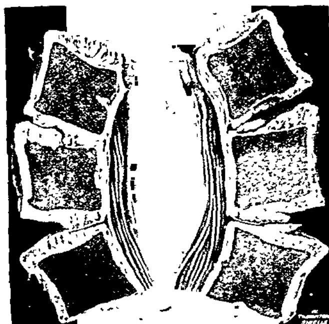


Fig. 750.—Double focus of tuberculous disease affecting chiefly the intervertebral discs.

There is a small sequestrum on the under side of the uppermost vertebra.

(*University College Hospital Museum*)

discs are destroyed, apart from a collapse of the bones, the deformity is more curved than angular. Marked lateral deformity is rarely seen. Deformity may be absent altogether, especially in dry caries. Should compression paraplegia occur in such a case, the diagnosis of intraspinal tumour is likely to be made.

When the process heals sclerosis takes place, and the bodies may become ankylosed together by bone. It has been customary to regard the collapse of the bones as an essential part of the healing process, but if the disease be recognized early while the bone is still

soft the deformity can be diminished, if not prevented, by suitable treatment.

Abscesses may form during the acute stage of the bony disease, or when the bone has almost healed. They tend to be limited by fascial planes, and, when they pass through such structures, do so through narrow openings. Generally speaking, their course is influenced by gravity. Their common positions will be considered under Symptoms and Physical Signs.

The extension of the disease to the spinal canal, giving rise to compression of the cord, may be in the form either of an abscess or of tuberculous granulation tissue; the process *usually remains outside* the dura mater, but occasionally a tuberculous meningitis arises. The cord is rarely compressed by the bony deformity, however acute the angle may be. (Fig. 752.) In a few cases compression has been due to a sort of lipomatous condition of the extradural tissue.

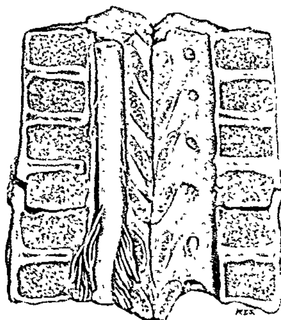


Fig. 751.—Lower five dorsal with 1st lumbar vertebræ, showing destruction of intervertebral disc and erosion of adjacent bones.

There is a small abscess-cavity on the front of the column.

(*University College Hospital Museum.*)

The spinal cord itself may be actually deformed or constricted, but more frequently the symptoms of compression are due to some interference with the blood supply, leading to œdema. Should the *œdema persist, softening* takes place with degeneration. The constriction of the spinal cord is localized, and rarely exceeds an inch in length.

Symptoms and physical signs.—The general health is affected, and the patient is very easily tired. Local pressure elicits tenderness. *Pain* occurs at the seat of the disease, and is of a dull aching character, increased by movement or by any sudden jar and relieved by rest. *Referred pain* occurs in the distribution of the nerve-roots pressed upon, and has the neuralgic character usually experi-

enced in such circumstances. It tends to occur in the periphery of the area of distribution, although it may be present as a girdle sensation. There may be hyperæsthesia in the same area. Owing to the frequency of dorsal caries, pain referred to the abdomen is common, and the complaint of "stomach-ache" in children may be the first symptom of the disease. Similarly, intercostal neuralgia should always induce careful examination of the upper dorsal spine.

Deformity and attitude.—The factors which affect the form of the spine are the destruction of the vertebræ and intervertebral

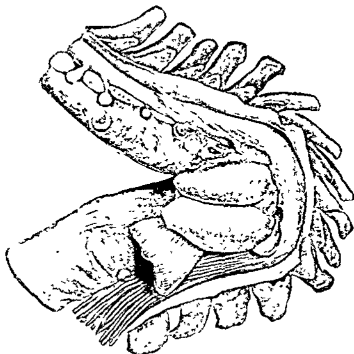


Fig. 752.—Specimen showing marked bony deformity and an abscess pressing on the cord.

At the time of death there was no paraplegia.

(*University College Hospital Museum.*)

discs, the rigidity which results from the attempt to prevent sudden movements or jars, and the compensating curves due to the necessity of holding the head erect.

The deformity resulting from the destruction of the bodies and intervertebral discs is best seen in the mid-dorsal region, where any increase of the normal curve is noticeable. In the cervical region the small depth of the bodies conceals deformity, which is perhaps only shown by an obliteration of the normal curve and shortening

of the neck. In the lumbar region the collapse of the bodies leads to a disappearance of the normal convexity forwards with some abnormal prominence of a spine. Lateral deformity of any marked degree occurs rarely.

In the attempt to minimize the movement of the affected portion of the spine the patient walks stiffly and supports himself by holding on to chairs, tables, etc., while in picking up things from the floor he bends the hips and knees to their full extent. In returning to the erect from the recumbent posture he either supports himself on surrounding objects, or "climbs up his own thighs" like a patient with pseudo-hypertrophic myopathy. In cervical caries the head is held stiffly, perhaps supported by the hands on the chin. In looking around the eyes are moved excessively or the whole body rotated. The spine below tends to lose its normal curves and become straightened. In disease of the atlanto-occipital joint the head tends to fall forwards.

The rigidity of the spine in the lower two-thirds may be tested by hyperextension in the prone position; the limitation of this movement is then very well seen.

Abscesses.—When the disease is in the bodies of the vertebræ, abscess-formation begins on the front of the spine. The abscesses tend to travel downwards beneath the anterior common ligament. In the cervical region a *retropharyngeal* collection forms, and, being limited by the prevertebral fascia in front, rarely bursts into the pharynx. As a rule it passes outwards beneath the vessels into the posterior triangle of the neck and presents in this situation. It may pass beneath the clavicle into the axilla; occasionally it continues downwards along the front of the spine into the mediastinum.

In the upper dorsal region a *mediastinal* abscess is formed. It may give rise to obstruction of the trachea, but is usually latent and only recognizable by X-rays. Pus may track along the intercostal space and present on the front of the thorax, or even in the anterior abdominal wall; such an abscess may be mistaken for one arising from disease of a rib. Sometimes the abscess follows the course of the posterior primary divisions of the dorsal nerves and presents in the back.

In the lower dorsal and in the lumbar region a *psoas* abscess is formed. The earliest sign of involvement of this muscle is loss of the movement of extension at the hip-joint, as tested with the patient prone, one hand of the observer laid on the pelvis and the other endeavouring to extend the thigh. Later on the abscess appears as a swelling beside the vertebral column; as it progresses it fills the iliac fossa and may present internally to the anterior superior iliac spine; or it may follow the psoas into the thigh, pass-

ing beneath the vessels and appearing on their inner side in Scarpa's triangle. Cases have occurred in which it has extended along the course of the vessels as far as the inner side of the ankle. In passing over the front of the hip-joint it may perforate the capsule and infect the joint. *It may pass from Scarpa's triangle to the back of* the thigh with the internal circumflex artery. Instead of running beneath Poupart's ligament it may enter the pelvis and, piercing the pelvic diaphragm, present in the ischio-rectal fossa, or, leaving the pelvis by the great sacro-sciatic foramen, it may be found beneath the glutei

Abscesses from this portion of the spine may present in the loin (*lumbar abscess*).

Compression paraplegia.—This complication occurs most commonly in caries of the dorsal region. Reference has already been made to the underlying pathological condition. It may occur with or without deformity. The onset is usually gradual, but occasionally is sudden, due to the rapid extension of an abscess into the vertebral canal or to a vascular lesion in the cord.

The lesion produced is an incomplete transverse one, and only very late does it become complete. The special characteristics of the compression are the gradual onset and the relative infrequency of root phenomena. Motor weakness of the upper motor neurone type is present in the lower limbs some time before anæsthesia or bladder symptoms make their appearance. When the anæsthesia is at all marked, bladder symptoms are certain to be present. Contractures are also frequently present in this stage.

Treatment.—As in tuberculosis elsewhere, the general hygienic treatment is far and away the most important. The results of treatment carried out under suitable conditions cannot be strictly compared with those obtained in city hospitals, so that whereas in the former circumstances almost any method of treatment may be successful, in the latter both conservative and active measures are disappointing

Apart from its complications, the treatment of tuberculosis of the spine resolves itself into the maintenance of rest for the diseased part, the prevention of increase of any deformity, and the attempt to diminish to some extent the deformity already present.

Rest in the acute stages of the disease must be obtained by recumbency, the patient being fixed on a firm bed and the spine stretched over a firm pillow placed beneath the deformity, care being taken to prevent sores. Extension in the sense of traction in the long axis of the body is of considerable use, counter-extension being obtained by raising the foot of the bed or by fixing the head. Phelps's box or a gas-pipe frame can be used, especially for children,

and allows the patient to be carried about. It is impossible in the space at our disposal to give details of apparatus.

The recumbent position should be maintained for at least a year, and until all signs of active disease, such as pain, local tenderness, and complications, have disappeared. After this the patient may be gradually allowed to assume the erect posture and be fixed in a plaster jacket. The jacket should be worn for another year, and then some lighter support such as a poroplastic or celluloid jacket applied. It must be clearly understood that plaster jackets do not absolutely fix the spine, but merely prevent any excessive or sudden movement.

Recently there have been attempts to improve and shorten the period of treatment by ankylosing the spinous processes to one another in the region of the disease; this has most frequently been carried out by the method of Albee, who unites the spinous processes by means of a graft taken from the tibia. In some cases, more especially adults, it seems to have been a success, but on the whole it has not rendered unnecessary the prolonged treatment recommended above.

Treatment of abscesses.—Apart from abscesses which compress the cord or obstruct respiration, the main object of this part of the treatment is to prevent a secondary infection. Rest alone may be sufficient to allow of the disappearance of the abscesses. If in spite of rest they progressively increase in size, something must be done to prevent them from reaching the surface, bursting, and becoming secondarily infected.

The removal of the focus of the disease is difficult, and the methods of dealing with abscesses are essentially not radical. They should never in any circumstances be drained, and the only point to be considered is the method by which they should be emptied.

The operative method—by which they are incised, flushed out, the lining membrane removed, and various drugs, such as iodoform emulsion, left in, the wound being then closed completely—has up till quite recently been considered the most satisfactory. The failures which have occurred have been due, apart from immediate sepsis, to a reaccumulation of the fluid and tuberculous invasion of the scar. As a result a sinus forms and secondary infection almost invariably takes place. If this method is used, it is essential that the scar be excised and the cavity emptied again before a sinus forms.

Recently the puncture and aspiration of abscesses has come to the fore. If the skin is slightly incised and then caused to slide a short distance before the hollow needle is plunged through the deeper tissues into the abscess, a valvular track is made, and evacuation, followed if desired by injection with iodine, or with formalin (2 per

cent.) and iodoform (10 per cent.) in glycerine (88 per cent.), can be accomplished with slight risk of secondary infection.

When a sinus has formed, it must be treated as a septic wound and efficient drainage ensured. The injection of bismuth pastes has sometimes, though not always, been successful as a curative measure, and is worth trying. (For formulæ, *see* p. 917.)

Treatment of paraplegia.—The orthopædic treatment should first be carried out completely, as in cases in which this complication is not present. Recovery follows in a large percentage of cases, even after many months in which no change has taken place. Should this treatment fail, operative measures are desirable.

It is well here, as in fracture, to consider what we hope to achieve by interference. The compression, as has been seen, may be brought about by granulation tissue, by abscess, or perhaps occasionally by bone; it may occur in cases in which the bony lesion is progressing, or in one in which it has almost healed.

In tuberculosis elsewhere in the body the ideal of an operation is to remove the disease radically, and only when this is possible are the results really satisfactory.

In the spine the difficulty of such an operation is enormous, so that operative treatment of paraplegia has been mainly limited to decompression. The procedure will be a *laminectomy*, with the scraping away of granulation tissue, opening of abscesses, and removal of sequestra. The results of such operations have been, on the whole, disappointing, especially in the cases in which the main focus of disease was active; and it is not easy to see how the opening of an abscess in connexion with disease of the body of a vertebra is likely to be permanently successful in such circumstances. If the case be one of those rare ones in which the bony disease is limited to the lamina, the result is likely to be good.

Attempts have been made to remove the original focus of disease by attacking the body of the vertebra from the side. In the neck this is comparatively easy; in the dorsal region it has been attempted by removing the vertebral ends of the ribs and the transverse processes (costo-transversectomy). In the case of an abscess compressing the cord this operation is just as likely to remove the cause of the compression as is a laminectomy, but with granulation tissue compressing the cord it can have no such direct effect. It is probably the operation indicated if a radiogram shows the presence of a mediastinal abscess.

The results of laminectomy would no doubt be better if the patient were at the same time kept under proper conditions; it would then prevent permanent damage to the cord while the main focus of disease was healing.

In performing a laminectomy the apex of the deformity is the best guide to the site of the compression, but it is not necessarily so, and *laminæ must* be *removed widely if* the compression is not found at that point. Great care must be taken not to wound the dura, since such an accident greatly increases the immediate and, by a tuberculous invasion of the arachnoid, the later mortality. If the disease of the vertebral body is active and considerable destruction of bone has taken place, great care should be taken in the movement of the patient during and after the operation. It is advisable that the wound should not be drained, owing to the risk of a secondary infection.

TUBERCULOSIS OF THE SACRO-ILIAC JOINT

This joint consists of an articulation between the lateral mass of the sacrum and the ilium. The articulating surfaces are irregular and are imperfectly covered by hyaline cartilage. There is a rudimentary synovial cavity. In normal circumstances very little movement takes place, but during pregnancy the ligaments are relaxed and some movement is possible.

Although this joint may be affected by any of the diseases to which *joints are liable—e.g. acute suppuration, gonorrhœa, etc.—it is its* invasion by tuberculosis to which most attention has been drawn, though even this condition is rare. It starts in the bones, either the sacrum or the ilium, more commonly in the former; sequestra are common. A pure synovial infection has not been demonstrated to exist. The disease is essentially an affection of adult life, and is not as a rule met with in children.

The chief feature of the **symptoms** is the pain in the region of the joint, with radiation in the distribution of the sciatic nerve (1st and 2nd sacral) This radiation is due to pressure on the nerve-roots in front of the joint. At first the pain is present only on exertion and is relieved by rest, but eventually it becomes constant. The patient develops a limp and takes very short steps, and all the weight is thrown on to the sound limb, so that the pelvis is dropped on this side and a compensatory curve arises in the spine with its convexity to the sound side. The limb on the diseased side is held straight.

There is tenderness over the joint, and, if destruction of the joint is considerable, pain is produced by pressure of the iliac bones together. When the patient is able to stand on the limb of the diseased side—i.e. if the pain is not too great—the pelvis is dropped on the opposite side, as in congenital dislocation of the hip. There may be swelling over the posterior aspect of the joint, and a rectal examination may discover some in front.

Abscesses develop on either the back or front of the joint, and are more frequent in front; from this situation they may track downwards and reach the ischio-rectal fossa, or they may pass out of the pelvis through the great sacro-sciatic foramen into the buttock. This latter route is by far the more common. Sometimes they come forward into the psoas muscle and present the features shown by these abscesses in caries of the spine, or they may follow the course of the obturator nerve into the thigh. Occasionally they burst into the rectum, bladder, or vagina. Behind they may present over the joint or pass upwards into the loin; or they may track downwards over the buttock, where they differ from abscesses coming from within the pelvis in being more superficial and in the swelling being continuous with that of the joint.

Diagnosis.—The first thing to decide is whether the pain is due to joint disease. All other causes of pain in the sciatic nerve must be excluded, and it must be remembered that the signs of joint disease, such as pain on pressure of the iliac bones together, may be absent in true cases of joint disease. Secondly, it is essential to decide whether the joint affection is tuberculous. In this connexion Goldthwait and Osgood have described cases of "relaxation of the sacro-iliac joint" which present symptoms and physical signs very similar to those seen in tuberculous disease; they are commonly associated with pregnancy, but a number have been reported in the male and in women who have not been pregnant. Some of these cases have been of traumatic origin. It is probable that the joint is more frequently affected by non-tuberculous processes than has been thought, and, in view of the almost constant involvement of the bone in tuberculosis, a radiogram showing destructive changes should be considered an essential physical sign of that disease. Osteo-arthritis shows bone changes in a radiogram—generally some lipping of the edges of the articular surfaces.

It must be remembered that the presence of an abscess in any of the above-mentioned situations may be the only sign of disease, apart from a demonstration of bone disease by a radiogram. This disease being always of bony origin, the X-rays are of great use in diagnosis.

Prognosis is bad, especially when abscesses have formed or sinuses are present, i.e. whenever tuberculous disease has been definitely shown to be present, so that it is possible that those cases which did not show these complications were not tuberculous (von Hook).

Treatment.—In the early stages this consists in rest in the recumbent position, so as to take the weight off the joint. Later, the patient may be allowed to walk with crutches and with a patten on

the column is very marked, and there is local tenderness. There is occasionally evidence of root pressure, such as radiating pains, and bladder symptoms have been noticed; it is these nervous symptoms which have led to typhoid spine being considered a neurotic affection. Suppuration is extremely rare. During the early stages of the disease there may be some pyrexia.

The diagnosis has to be made from tuberculous caries; the history of enteric fever, together with a positive Widal reaction, will point to a typhoid spine.

The treatment consists in rest in the recumbent position as for tuberculous caries. The pain rapidly disappears, and, except for some slight deformity and local stiffness, the disease clears up completely in less than twelve months.

CHARCOT'S DISEASE OF THE VERTEBRAL COLUMN

A condition corresponding to that met with in other joints, such as the knee in tabes dorsalis, is occasionally found in the spine. It occurs most commonly in the lumbar region, and gives rise to an angular kyphotic deformity of an irregular kind. Sometimes there is a fracture of a vertebra, while spondylo-listhesis may be seen at the lumbo-sacral joint. The condition is painless and merely gives rise to a sense of weakness of the back. Treatment consists in fitting some support to the spine.

TUMOURS OF THE VERTEBRÆ

The varieties of growth met with in the vertebræ do not differ from those in bone generally. Primary tumours are always connective-tissue tumours, and may be either benign or malignant.

Chondromas are rare, and may be associated with similar tumours elsewhere in the skeleton. They only lead to symptoms when they compress the cord or nerves. Angioma has been described. Primary sarcoma may be either periosteal or central. Secondary sarcoma is not so common as primary. Multiple myeloma occurs and frequently gives rise to cord symptoms; in these cases albumose is found in the urine, though it may not be constantly present. Carcinoma is invariably secondary, and may be due to the infiltration of a neighbouring growth or to a deposit from a more distant primary source. There are certain growths which tend to give rise to secondary deposits in bone, and of these the most frequent are those of the breast, thyroid, bronchus, stomach, prostate, and uterus, together with hypernephromas. These secondary deposits are usually in the body of the vertebra.

The malignant tumours, both primary and secondary, are ten times more common than the benign; they tend to involve more

than one vertebra, and, generally speaking, are of an osteoclastic nature. As a result the bodies of the vertebræ tend to collapse; and, as in other bones, spontaneous fracture with displacement is liable to occur.

The **symptoms and physical signs** may be grouped into those due to the bone involvement, those due to pressure on nerve-roots, and those due to pressure on the spinal cord.

Bone involvement.—Local pain and tenderness may occur, and, as in tuberculous caries, are increased by movement or sudden jars. Deformity is sometimes present, and since, as a rule, more than one vertebra is involved, the deformity is not angular but curved. It is usually an antero-posterior deformity. Rarely there is local swelling due to the tumour itself. Rigidity is generally present.

Pressure on nerve-roots.—This is the outstanding feature of these cases, and causes the usual characteristic root pains. The pain is very severe, and may be paroxysmal in character, with long intervals of freedom. In this way it may reproduce almost exactly the pain of biliary or renal colic. It is usually present for some time without any clinical evidence of bone involvement or of pressure on the cord. In all cases in which severe pains of this type occur it is important to examine the breast and other organs for a primary growth, while the presence of enlarged lymphatic glands, e g. in the left posterior triangle, may give evidence of some thoracic or abdominal neoplasm.

Compression paraplegia.—The main feature is rapidity of onset, which may equal that of a transverse myelitis. As a rule, the paraplegia is also more complete than that due to other causes of compression, so that loss of sensation and bladder symptoms are present from the beginning.

The X-rays may show rarefaction in the bodies of the vertebræ.

Treatment.—Except in the case of a benign tumour, a few of which have been operated upon successfully, only palliative measures can be adopted.

CONDITIONS OTHER THAN VERTEBRAL LEADING TO NARROWING OF THE SPINAL CANAL

This group contains a large variety of processes leading to a localized compression of the cord. As causes of this condition they are much less common than those arising from the vertebræ. It is customary to regard them all as tumours of the cord, whether they are of neoplastic or of infective origin, but they are only tumours in the clinical sense, and it seems better to limit the term tumour to those of neoplastic nature. The following classifica-

tion indicates the positions at which the processes are most likely to arise:—

I. New growths of the spinal cord and meninges.

Meningeal.—A. Extradural:

Lipoma, *very often congenital and occurring* in connexion with spina bifida.

B. Intradural:

Primary sarcoma, fibroma, myxoma, lipoma, *endothelioma*, psammoma, neuroma and neuro-fibroma (multiple), angioma, and *mixed forms*. Secondary carcinoma rarely.

Intramedullary. Glioma, sarcoma, and myxoma.

II. Infective granulomata.

Tuberculosis, usually intramedullary, occurring as a solitary tuberculoma unassociated with meningitis.

Syphilis (gumma), usually meningeal and intradural, occasionally intramedullary.

III. Parasitic cysts.

Cysticercus cellulosæ, usually intradural, rarely intramedullary.

Hydatids, usually extradural, between the arches and dura mater.

IV. Localized chronic serous meningitis.

Intradural.

V. Hypertrophic cervical pachymeningitis.

Intradural tumours are much more common than extradural, meningeal than intramedullary.

The intradural (meningeal) are more frequent in the dorsal region, *while the intramedullary tend to occur at the cervical and lumbar* swellings of the cord.

New growths are usually single, with the exception of neuro-fibromas (which occur in connexion with general neuro-fibromatosis), multiple sarcomas, and the rare secondary deposits. They tend to be oval, with the long axis in the direction of the cord, but generally speaking the compression does not extend in an upward direction. The cord may be deformed, but as a rule it is the interference with its circulation which produces the symptoms and leads eventually to softening. The extramedullary tumours have very little tendency to invade the cord. They are *all of exceedingly* slow growth, and when removed are not prone to recur.

Conglomerate tuberculosis occurs in the medulla, most commonly at *the* lower end of the cord, and may be associated with other tuberculous foci in the nervous system. It is more rapid in its course than the new growths.

Gummata tend to be multiple, and, as stated above, are more commonly meningeal in origin.

Hydatid cysts tend to occur in two regions—(1) the upper dorsal

region (2nd to 6th), having invaded the canal from the mediastinum; and (2) the lumbo-sacral region, from the pelvic and abdominal retro-peritoneal tissue. Occasionally the bodies of the vertebræ are invaded, but as a rule the disease spreads through the intervertebral foramina.

Localized chronic serous meningitis.[1] (See Injuries of Spinal Cord, p. 586.)

Symptoms and signs of tumours of the cord.—Broadly, the symptoms of *extramedullary* tumours group themselves into three periods: (1) The symptoms due to root involvement, at first on one side and then on both; this period may be very long, i.e. years before the other symptoms appear; there may be remissions. (2) Those due to unilateral pressure on the cord, giving the characteristic Brown-Séquard phenomenon; this period is usually short, and may not be observed. (3) Those due to a transverse lesion of the cord, at first incomplete, finally complete.

The symptoms of *intramedullary* differ from those of extra-medullary tumours in the absence of root pains, unless the growth arises in the neighbourhood of the posterior horn of the grey matter. Signs of a unilateral lesion are rarely present, so that an intramedullary tumour usually shows itself as a progressive transverse lesion. Trophic phenomena are more common, and the upper limit of the symptoms is prone to extend, whereas in the extramedullary it usually remains stationary.

Diagnosis.—The diagnosis of tumour of the cord—using "tumour" in the clinical sense—is a difficult one. From a *transverse myelitis* it is distinguished by its steadily progressive course, as opposed to the rapid onset of that disease with its tendency to subsequent improvement. From *syringo-myelia*, which is essentially an intramedullary tumour, it may be diagnosed by the greater extent of the local symptoms and signs due to local involvement of the grey matter and by the trophic phenomena characteristic of that condition.

From the surgical point of view the most important differential diagnosis is from *vertebral disease*, and the importance of an examination of the vertebral column in all cases of compression paraplegia cannot be too strongly emphasized. The evidence of destruction of the vertebræ may be actual deformity, usually of a flexion character, rigidity of a portion of the column, or changes in the bone seen in a radiogram; while collateral evidence may be discovered, such as the presence of abscesses in caries, or tuberculosis in other organs, or the finding of a primary malignant growth in some organ such as the breast or the thyroid.

Vertebral disease being excluded, and *syphilis* having been eliminated by a negative Wassermann test and by the absence of

[1] Sir Victor Horsley, *Brit. Med. Journ.*, 1909.

subsequent improvement under specific treatment, it may be said that a slowly progressive, local, transverse lesion of the cord, especially if it have shown the course characteristic of a meningeal tumour, is an indication for operative interference.

The diagnosis of the level of the lesion is based on the upper limit of the sensory symptoms and signs, the site of the root pains being of especial importance. It must be remembered that the tumour tends to be found at a higher level than that at which it has been localized, although occasionally it has been found lower down. The information to be obtained by lumbar puncture is of great value. (*See* p. 576.)

Operative treatment. — The cord is approached by a laminectomy, at least three laminæ being removed. The dura having been exposed, it is important to exclude any extradural cause of compression; therefore the bodies of the vertebræ should be carefully examined with a probe.

If there is a tumour intradurally the dura may not pulsate opposite and below it, and thus some indication of the site of the compression may be obtained. The tumour may be felt through the dura. If nothing can be felt and pulsation is absent, another lamina above should be removed before the dura is opened; a large number of laminæ can be removed with safety. The dura should be opened in all cases in which no extradural cause of compression has been found. If the tumour is not seen, the sac should be carefully probed upwards and downwards for obstruction. The existence of an obstruction above the region exposed is suggested by a cessation in the flow of cerebro-spinal fluid and by venous congestion of the visible part of the cord. It may be necessary in removing a tumour to excise one or more nerve-roots, and in the dorsal region this will cause no inconvenience. If the tumour is adherent to the dura a portion of this membrane should be excised.

Intramedullary processes are seldom amenable to operative interference, but two cases have been reported of successful removal of such tumours—one a tuberculoma, by Veraguth and Brun; the other a glio-sarcoma, by Elsberg and Beer. The latter was dealt with in two stages, the cord being exposed and incised over the tumour, the wound then closed, and another operation performed a week afterwards for the removal of the tumour.

It is probably not necessary to suture the dura, and in meningitis circumscripta it is undesirable. The wound in the muscles and the skin must be completely closed in layers, and not drained. As a rule the wound heals by first intention, but occasionally cerebrospinal fluid escapes. Should this occur, and persist for more than a day or two, re-suture of the wound will be necessary.

Shock following the operation may be marked, and occasionally leads to a fatal result. Pneumonia and extension of an infection of the bladder to the kidneys sometimes cause death.

SPINA BIFIDA

The spinal cord is formed by a depression of the epiblast. The lips of the depression fold over and unite to form the central canal of the cord. The skin then unites over the cord, and the mesoblast containing the laminæ of the vertebræ grows in between the cord and the skin, so as to separate these two epiblastic structures. The closure of the central canal begins in the mid-dorsal region and spreads in a cephalic and a caudal direction, the lat

forms ·

In length

to the lumbar region (*partial rachischisis*). In rachischisis (Fig 753) the bottom of the depression shows a narrow band of reddish, velvety appearance which represents the spinal cord (area medullo-vasculosa); at each side of this is a zone covered by a thin layer of epithelium (zona *epithelio-serosa*), *resting* on the pia; and beyond this is more or less normal skin adherent to the arachnoid and dura mater. In partial rachischisis a swelling may be formed by the collection

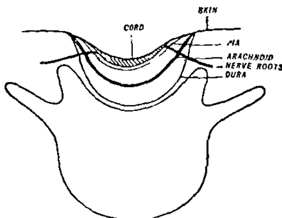


Fig. 753.—Rachischisis.

of the cerebro-spinal fluid in front of the cord, which pushes the cord backwards, there being no support in this direction; this is then known as an *open myelo-meningocele*. In it the area medullo-vasculosa lies along the top of the swelling; at either end there may be holes leading into the central canal of the cord. The *nerves run either in the lateral walls of the* sac or across the cavity to their respective intervertebral foramina.

If the lips of the medullary groove unite, the skin always unites as well, so that the remaining forms of spina bifida are those due to a mesoblastic defect. Swellings may be formed in three ways · (1) The cord may be pushed

and covered on the outside by skin. This form is called a *meningocele* (Fig. 756), and is occasionally present without absence of the vertebral

laminæ; it then herniates between two laminæ. Sometimes a combinati of syringo-myelocele and meningocele is encountered.

Lastly there occur cases *in which there are defects of the laminæ,* u associated with swellin of the cord or mening This form is designat *spina bifida occulta.* T skin over these defe usually shows excessi growth of hair, whi may be so marked to produce a tail-like a pearance. It is sometim dimpled or scarred, a there may be small t mours of the skin pr sent. Subcutaneousl various tumours are m with—lipomas, my lipomas, teratomas, e Spina bifida is co monest in the lumb sacral region; sometim it is met with in t cervical, and much more rarely in the dorsal region.

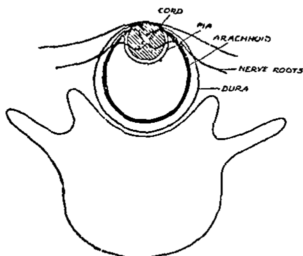
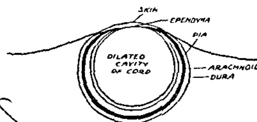


Fig. 754 —Closed myelo-meningocele.

Connected with spina bifida are two classes of lesions: (1) Those d directly to the involvement of the cord, e.g. paralysis with resulti deformities of the lower limbs, paralysis of the bladder and rectum, and trophic lesions such as perforating ulcer. (2) Associated defects such as hydrocephalus, absence or malformation of the vertebral bodies leading to scoliosis, absence of ribs, defects of the intestinal canal, ectopia vesicæ, and deformities of the lower limbs apart from nerve involvement. To the second group probably belongs the condition named spina bifida anterior, in which a hernia of the meninges takes place ventrally through a defect in the bodies of the vertebræ. This is a very rare condition.



ringo-myeloce

The myelo-men ocele is said to be th nest form, uthors state meningocele ent. Most born with s are not via

A *myelo-meningocele* is always a flattened tumour, and the groove along its summit indicates the attachment of the cord, while by transillumination the nerve-roots may be seen attached to its walls. Paralyses, sphincter troubles, and trophic ulcers are more common than in meningoceles, whilst the bony defect is usually greater. Myelo-meningoceles mainly occur in the lumbar region. A *syringo-myelocele* does not show any nerves in the wall of the sac, and is usually associated with nervous lesions such as are met with in myelo meningocele.

Pressure on the sac of a spina bifida may cause bulging of the fontanelles and may produce unconsciousness. The swelling of a spina bifida tends to increase in size, and occasionally it bursts; this bursting is rendered more likely by the ulceration of its coverings and the defective skin. Infection takes place, as a rule, and sooner or later leads to death. Death sometimes occurs as a result of the sudden escape of cerebro-spinal fluid. The paralysis of the bladder leads eventually to infection of the urinary tract, and is another cause of death. The vast majority of cases born alive die within the first year, only about 3 to 4 per cent. living more than five years. In most of these cases the tumour is a meningocele.

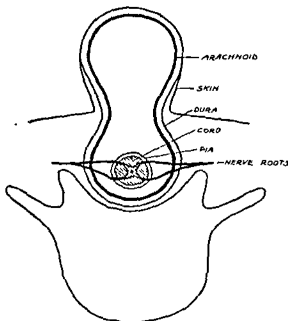


Fig. 756.—Meningocele.

Spina bifida occulta.—Clinically, the importance of this condition consists in its coming under observation owing to the secondary effects on the cord and nerve-roots rather than because of the local condition in the vertebral column. These secondary effects show themselves in paralytic deformities of the lower limbs, trophic ulcers, and sphincter trouble. They may be present at birth, and then are due to associated defects of the spinal cord, but they may only [illegible] ral column [illegible] y the dis- [illegible] the latter [illegible] ed by the growth of the bone. In these circumstances improvement has been brought about by operative interference and division of the attachment. Occasionally pressure symptoms are due to the growth of the associated tumour, and are relieved by its removal.

Treatment of spina bifida.—The object of operation is mainly to prevent infection of the meninges; its value as a means of preventing

or relieving the secondary effects, such as paralyses, is very doubtful, and can only obtain when these result from pressure within the sac.

The open forms should never be interfered with. It is doubtful whether the closed myelo-meningocele or the syringo-myelocele is benefited by operation, since in both some destruction of the cord or nerve-roots is almost certain to be incurred by the procedure. They should only be operated upon if increasing in size, and even then, if the operation is successful in closing the defect, hydrocephalus is likely to supervene. Meningoceles are the most satisfactory cases for operation.

With regard to the age at which to operate, it is doubtful whether sur gical intervention is likely to save any patients who without it would die in the first five years; and since most of the cases that survive this period are meningoceles, it is perhaps better to wait until the completion of the fifth year before interfering, unless operation is indicated by increasing size or threatened ulceration; in such the minor operation of aspiration may be tried

For the operation the patient should be prone with the buttocks raised. The skin should be carefully disinfected, and any ulceration touched with pure carbolic. The sac should be opened at the side to avoid an adherent cord, and the interior explored. If it is a myelo-meningocele the cord should be isolated and buried in the spinal canal, the defect in the skin being closed by flaps. It is important to obtain primary union, otherwise leaking of cerebro-spinal fluid will take place with subsequent meningitis. The plastic operations designed to cover the defect with bone or muscle are of little value. If the swelling is a meningocele the neck of the sac should be tied off and the skin sutured over it.

SPINAL OPERATIONS FOR THE TREATMENT OF PAIN

Intractable pain sufficiently severe to justify any hopeful surgical measure, however drastic, is not uncommon, and occurs in various circumstances which will here be roughly classified for practical purposes and without attempting precise pathological definition.

1. *Following gross nerve injuries.*—Any nerve injury is a potential source of serious and persistent pain. A simple section of a nerve followed by suture may on this account prove a most disabling injury. It is, however, the injuries from gunshot wounds, from crushing and tearing violence, and from amputation, especially when either is accompanied by sepsis, that are most apt to be followed by pain of this grade. This class includes many cauda-equina injuries.

2. *Due to ascending neuritis*—Although this condition occurs often in the preceding class, and is perhaps responsible for the pain in most cases, the characteristic form of the disease is that which follows trivial, usually infected wounds of the peripheral parts of the limbs. It is a not very uncommon sequel of insignificant whitlows of the fingers. Redness, acute hypersensitiveness, and trophic changes gradually spread up the limb from the original focus. Spontaneous and induced pain, and hypersensitiveness, may be such as practically to disable the whole limb The condition is presumably due to an infective change spreading up the substance of the nerves along the

current of natural drainage and through them towards the spinal cord.

3. *Pressure on nerve-trunks* by fibrous tissue, bone, inflammatory products, aneurysm, and benign tumours such as fibroma and osteoma In these cases the nerve-sheath remains intact, and no progressive upwardly-spreading condition occurs in the nerve.

4. *Implication in malignant tumours.*—Here the effect is usually produced by pressure, but sometimes through actual invasion of the nerve by the tumour substance.

5. *The painful crises of tabes dorsalis.*

When all peripheral methods of dealing with the pain have been used without success, recourse has been had to intraspinal operations; the corresponding posterior roots have been divided, or the lateral tract of the cord, or even the whole cord, has been cut through. This last desperate expedient can very rarely be justified. Division of posterior roots has given very variable results—in some cases complete success, in other cases complete failure. The usefulness of posterior-root division depends apparently on the period of the condition at which it is done and the nature of the condition itself. The latter factor is the more important. When there is reason to suspect an ascending process in the nerve, posterior-root division almost always fails; when there is no spreading process in the nerve but only a local pressure, root division practically always succeeds, though it is naturally, from the nature of the case, rarely called for. It is generally assumed that the failure of root division in the treatment of ascending conditions is due to its being too long delayed. This is possibly the case, but it is doubtful whether any patient would submit to so formidable an operation at a period early enough to give hope of success. To have any prospect of succeeding, posterior-root division must be very thorough, and complete anæsthesia of the painful region must be aimed at. This, of course, if a large part of a limb is in question, causes a disabling amount of ataxy and hypotonus in the affected part. For the *gastric crises* of tabes some of the posterior roots of the dorsal region have been divided. The operation here has the advantage of not producing any notable disability, but its value is doubtful, and the symptoms have been known to recur after apparent success.

It is probable that in most cases where root division for pain has failed the symptom has been due to some change having spread into the spinal cord from the nerves. This view is suggested by the fact that division of the pain fibres in the lateral tract of the opposite side has succeeded after root division has failed At any rate, for cases of intractable pain following nerve injury and presumably due to an ascending process in the nerve, lateral-tract division is more promising than root division. The principle of the operation is the division of

the elevator. The forceps should be of strong steel, and the blades wedge-shaped, so as to fit accurately on the neck of the tooth. The elevator should be held in the dinner-knife position, with the finger near the tip to minimize any damage should the instrument slip.

4. The operation is divided into three stages (Tomes): (1) the seizure of the tooth; (2) the destruction of its membranous connexion with the socket; (3) its removal. The first stage is performed by applying one blade to the more obscured side of the tooth and gently closing the other blade on the opposite side, taking care not to include any of the gum within the grasp of the instrument. The forceps is next pressed firmly towards the root of the tooth with a slight wriggling motion. The tooth having been seized, its membranous connexions are severed either by a steady rotatory or a lateral rocking movement, rotation being only applicable in the case of the upper incisors and the lower bicuspids. The third stage is a continuation of the last, and consists in applying traction in the long axis of the tooth, and also in that of the least resistance; the outer alveolar plate being thinner than the inner, the force is nearly always to be applied in an outward direction.

When the elevator is used, as in the case of the lower wisdom-teeth, the roots of which often curve backwards, the operation is as follows: The alveolus being grasped between the finger and thumb and the cheek kept out of the way, the point of the instrument is thrust down between the tooth and the alveolus which separates it from the next molar, the handle pointing upwards, forwards, and slightly outwards. Then using the tooth in front as a fulcrum, the handle is depressed and the tooth raised in its socket. When one depression is insufficient to free the tooth, the handle is again raised and the point thrust still farther under the root of the tooth, the manœuvre being repeated until the tooth is loose enough to be removed with the left hand. The gum sometimes adheres firmly to the back of the tooth and may have to be divided with scissors. Care must be taken to prevent the instrument from slipping and wounding the floor of the mouth. Clumsiness may fracture the neighbouring molar.

5. When teeth are removed under general anæsthetics other than nitrous oxide or ethyl chloride, the patient should lie on the back with the head supported on a sand-bag and steadied by the anæsthetist. In nearly all fatalities which have occurred under anæsthetics during extraction of teeth, this simple precaution against syncope has been neglected. When operating under gas, time is of great importance; therefore, if more than one tooth is to be removed, the surgeon should settle beforehand the order in which he means to attack them. Lower teeth should be removed before upper ones, as the bleeding from these

will not impair the view of those to follow. For the same reason back teeth should be dealt with before front ones, and stumps before whole teeth. The mouth should not be gagged too widely open, and the prop, when possible, should be placed upon the side opposite to that to be operated upon. Each tooth must be removed from the mouth before the next is dealt with, to prevent the possibility of one slipping back into the larynx.

Difficulties may be met with in dealing with overcrowded and irregular teeth. Should the wrong tooth be drawn, or a neighbouring tooth accidentally loosened, it should be pressed firmly back into its socket after the operation is completed, the patient instructed to keep his jaw firmly closed, and a four-tailed bandage applied; in a large number of cases the tooth will become firmly implanted again.

When the crown of the tooth is broken off, the individual fangs must be sought and extracted separately. Laceration of the gum and fracture of a small portion of the alveolar plate are often unavoidable, and may give rise to great pain for a few days after operation; but fracture of the body of the bone and dislocation of the condyle are accidents for which there can be little excuse. The bleeding, as a rule, stops on rinsing out the mouth with warm water, but if it continues the socket may be temporarily plugged with gauze dipped in a solution of adrenalin, and pressure made over the pad with the thumb for a few minutes. In hæmophilic children the teeth should on no account be extracted, or fatal oozing is very likely to result.

AFFECTIONS OF THE GUMS

Spongy gums are not infrequently caused by sepsis around the necks of the teeth, by scurvy and purpura, or by the administration of mercury. In children under one year spongy and bleeding gums are a manifestation of scurvy from improper feeding. The gums become œdematous and congested at the margins opposite the teeth; they bleed easily, and may be ulcerated.

The **treatment** consists in the free use of antiseptic and astringent mouth-washes after rectifying the determining factor in each case.

Hypertrophy of the gums is a rare condition of fibrous overgrowth usually confined to their dental margins. As it appears to start round the necks of erupting teeth, it is usually seen in early life, but, being a very chronic disease, it may also be found in adults It is frequently associated with defective mental activity. The gum is irregularly enlarged, so that the teeth, with the exception of their crowns, appear buried in firm nodular tissue, which may be congested, ulcerated, and easily made to bleed, or may be firm and elastic to the touch and pale in colour The increased growth is

sometimes limited to one side, but usually affects the whole of one jaw; in bad cases it may affect both upper and lower jaws, and even the hard palate. The gum may reach such a size as to cause the cheeks to bulge, and may interfere so greatly with mastication that the taking of solid food becomes impossible.

Treatment consists in paring away the hypertrophied tissue and removing the alveolar margins round the affected teeth. In some cases the teeth themselves have to be sacrificed; this in the case of a temporary set is a comparatively small matter. If a portion of the bone is not removed, recurrence is almost sure to take place. The thermo-cautery will be found very useful in destroying the bone and controlling the hæmorrhage.

Polypus of the gum, or, as it used to be termed, simple epulis, is a local hypertrophy of the gum, the direct result of irritation. It is generally found in connexion with a ragged stump, tartar round the teeth, or irritation from a badly fitting plate. The growth starts usually on the outer side of the teeth, and may be pedunculated or sessile; in the latter case it may spread inwards between the teeth. When allowed to grow to a large size it may be mistaken for an epulis, but may be distinguished by its superficial nature and by its lack of connexion with the periosteum.

Treatment consists in snipping off the polypus or destroying it with the cautery, and at the same time attending to the irritative cause. If the cause is effectively removed, there is no recurrence.

Epulis is the name given to a growth which, although it appears to be an affection of the gum, really springs from the periosteum of the alveolus, the gum being stretched over its surface. The usual form is a simple fibrous tumour. Other forms are more *cellular* in character, and show a low degree of malignancy. These are really myelomas; often the tumour contains multinucleated giant cells. An epulis usually commences between two adjacent teeth, which become widely separated by its development; sometimes it is *only* attached to the inner or outer alveolar plate, and then displaces the teeth outwards or inwards. In some instances tumours of t[illegible] variety begin in connexion w[illegible] lveolo-dental perio[illegible] are attached to a *tooth*, *com*[illegible] *hen this is extract*[illegible] commencing in the depths of [illegible] deeply in the ja[illegible] may be incorporated in the [illegible] is is the case almost always of the myeloid [illegible] des are firm t[illegible] often pale in colour, and as [illegible] *ful*, *though* t[illegible] may be[illegible] ed by the op[illegible] ey are of s[illegible] may [illegible] e size and cau[illegible] ity by prot[illegible] the [illegible] ch case the [illegible] becomes d[illegible] and [illegible]

Treatment aims at the removal of the tumour, together with the portion of periosteum and bone from which it springs. The prominent part of the tumour is cut away with gouge-forceps or chisel, and then one or both teeth are removed, and a V-shaped piece of the alveolus cut away with bone-forceps from between the tooth sockets. In the case of myeloid epulides, which can be recognized by their darker colour, the bone should be opened up more freely and the interior cleared out with the gouge or the sharp spoon. To destroy any doubtful tissue, it is a good plan to use the thermo-cautery, or to pack the cavity with chloride of zinc, 40 gr. to the ounce, or with pure phenol. If recurrence should take place the procedure must be repeated.

INFLAMMATORY CONDITIONS OF THE JAWS

A. General

Inflammatory conditions of the two jaws are common on account of the intimate relationship between these bones and the teeth, most of the trouble commencing as a periodontitis (alveolar periostitis) in connexion with the latter structures.

A **diffused periostitis** may be due to injury, to the irritation of a badly fitting plate, or to the septic condition of carious teeth, or may be the result of prolonged exposure to the fumes of yellow phosphorus or the administration of mercury in large doses. Occasionally it follows an exanthem, or its onset may be determined by gout, rheumatism, syphilis, or the advent of the tubercle bacillus. It may also be an early symptom of necrosis of a part of the bone, or of the onset of malignant disease. A generalized peridental inflammation is known to occur occasionally in diabetic subjects, the teeth becoming loose and falling out.

Symptoms.—The earliest symptom of a diffused alveolar periostitis is an uneasy feeling in the teeth, which gradually becomes worse, until the least pressure causes acute pain. The pain is usually worse at night, while in the rheumatic form it is especially marked during cold and damp weather; in this form suppuration is most unusual. There are redness and œdema of the gums, loosening of the teeth, and perhaps swelling of the face, accompanied by a certain amount of constitutional disturbance. The subsequent course of events depends very much on the cause of the trouble. When it is due to phosphorus or mercury, salivation, suppuration, and extensive necrosis of the jaw often ensue; even in the less severe forms the death of a small area of bone may take place.

Treatment consists in rectifying any known cause of the disease, such as bad teeth or exposure to mercury or phosphorus, and in apply-

ing suitable remedies in the case of rheumatism and syphilis. Locally, the mouth should be kept aseptic with antiseptic mouth-washes, while local depletion by scarification of the gums relieves the pain.

B. Localized

These inflammatory conditions may be divided into the acute form, or alveolar abscess, and the more chronic forms, which are less noticeable but which have far-reaching effects.

Alveolar abscess (Fig. 757) always results from the advent of septic organisms, which usually gain access through a carious area in the



Fig 757.—Alveolar abscess.

A, Carious area infecting pulp cavity, B, alveolar abscess opening through outer wall of alveolus to form gum-boil, C, D, another route by which a gum-boil may form on palate, E, abscess infecting antrum, F, nasal cavity

crown of a tooth, spread to the pulp, pass down the canal to the apex of the fang, and infect the deeper parts of the socket. If the inflammation is not arrested the cementum is detached from the periosteum, and the space so formed becomes filled with pus which increases rapidly in amount, the space meanwhile being enlarged by absorption of bone. That part of the socket which is least resistant undergoes most absorption, and is eventually perforated, the pus raising up the tissues to form an abscess outside the bone; this eventually ruptures, and the pus is discharged. The outer wall of the alveolar process is the thinner and less resistant, and is therefore the common situation in which to find the "gum-boil." The direction which the pus may take,

however, is very variable. As a rule it pierces the outer surface of the gum within the mouth on a level with the apex of the affected fang; but if the abscess be large and the wall resistant, it may find its way out between the gum and the neck of the loosened tooth. Other and less frequent directions must be noted. The inner plate of the alveolus may be perforated, and the abscess form on one side of the hard palate or inner side of the lower jaw. In the case of the upper bicuspids, molars, and occasionally the canines, the pus may find its way into the antrum and set up empyema of that cavity. When the upper incisors are at fault, an opening may form in the floor of the nose, a sinus being found at the apex of a small teat-like papilla easily seen on examining the nostrils. Openings on the face, though usually seen in the case of alveolar abscesses connected with the lower jaw, may result from abscesses of the upper jaw; for example, a sinus at the inner canthus of the eye may be secondary to suppuration around an upper canine. An abscess opening near the symphysis menti is usually due to disease of or around a lower incisor, one near the angle of the jaw to a lower wisdom-tooth. Sometimes openings are found in the floor of the mouth. On rare occasions the pus has burrowed along the layers of the cervical fascia and opened as far down as the clavicle.

Symptoms.—In the early stages there is merely an uneasy feeling in the tooth, which gradually becomes painful and feels as if it were raised and slightly loose in the socket. The pain is relieved by biting on it and by pulling it or pushing it sideways. Gradually the pain assumes a more acute and throbbing character and, especially in children, severe constitutional symptoms may supervene. The temperature runs up to 102° F. or even higher, the pulse is rapid, the jaw first and then the face become swollen, and delirium even may be present. The tooth is very tender to touch, and acutely painful if tapped; the surrounding gum assumes a bright-red appearance. The acute symptoms last as long as the pus is pent up under pressure, and subside as soon as there is an outlet through the bone, although the pus may not be evacuated from the "gum-boil" till some days later

Complications and sequelæ.—These are seldom met with, but occasionally, when treatment is required and not available, untoward symptoms may develop. Among these infection of the antrum of Highmore, inflammation and suppuration of the neighbouring lymphatic glands, or the persistence of a sinus, with a lowering of general health characterized by anæmia, etc., consequent on the swallowing of pus, are the commonest results. Among the rarer complications recorded are cellulitis of the neck, with fatal œdema glottidis, pyæmia with secondary abscesses elsewhere, venous throm-

bosis of the veins of the face with spread to the intracranial *sinuses*, causing coma and death, and, lastly, necrosis of parts or the whole of the jaw.

Treatment.—The vast majority of alveolar abscesses, whether treated or left alone, clear up without *any serious trouble. If possible*, the source of the inflammation should at once be got rid of. If there [illegible]

undertaken after injecting a local anæsthetic deeply into the jaw. If, in spite of treatment, an abscess forms, an attempt may be made to save the tooth by incising the gum and letting out the pus; but the tooth should be extracted at once if pus is already welling up between it and the gum, if there is any sign of the abscess pointing on the skin, extending to the antrum, or burrowing deeply, or if any severe complications occur. The tooth is usually very easily extracted, and is followed by a gush of pus. The socket then heals by granulation In dealing with an abscess on the outer side of the gum of the lower jaw, the edge of the knife should be directed towards the bone; on more than one occasion neglect of this precaution and sudden movement on the part of the patient have been responsible for division of the facial artery. In opening abscesses on the palate, the same caution is necessary to avoid injury to the large palatine vessels. Every means should be taken to prevent an abscess from opening on the skin surface. Even when pointing has actually occurred, an external opening may be prevented by free drainage into the mouth, the skin at the same time being strengthened by painting over it a layer of gauze and collodion.

The after-treatment consists in frequently rinsing out the mouth with antiseptic lotions, such as potassium permanganate, or carbolic-acid and hydrogen-peroxide solutions, at the same time giving a brisk purge and attending to the general health. Occasionally sinuses remain for a long time, and when opening on the skin produce unsightly scars. They heal up after the removal of any dead fang which is acting as a sequestrum. These tracks may open a long way from the fang at which the abscess originated, and a careful examination is required before the real cause is recognized

Pyorrhœa alveolaris, or Rigg's disease, is the name given to a very common condition of oral sepsis which may have severe constitutional effects. Normally the gum just overlaps the sides of the enamel of the crown, while between the teeth it reaches a considerably higher level. Unless scrupulous attention is paid to the cleaning of the te[illegible] lodge in the

cleft between the gum and the teeth; here decomposition takes place with infection of the periodontal membrane, and later of the alveolar bone. The disease is at first confined to one or two teeth, usually the lower incisors, but tends to spread gradually from one tooth to another till all are affected. It is very chronic, and is rarely well-established before adult life; its spread is slow, though sometimes acute exacerbations occur. Recent investigation has shown that sometimes the condition is caused by an abscess at the root of one tooth, the pus oozing up between the tooth and the gum and infecting the adjacent tooth-sockets. This can only be made out by the X-rays.

In the early stages the gum has a bluish-red appearance, due to irritation and congestion; later it becomes swollen and tender, and is easily made to bleed. When pus can be squeezed from the sulcus, ulceration has begun. With the ulceration and destruction of the periodontal membrane the alveolar margin is gradually absorbed, leaving pockets between the teeth and the swollen gum. Stagnation becomes more and more marked in these pockets, which are further occluded by the amount of tartar deposited round the necks of the teeth. As the bone is absorbed the gum begins to shrink, so that the teeth look elongated; the bone of the outer alveolar plate may be absorbed to such an extent that the tooth is exposed from crown to fang: the inner plate suffers to a less extent. The patient's breath becomes sour and fetid, and he complains of a bad taste in the mouth. The exposure of the necks of the teeth makes them more sensitive to touch, to heat, and to cold, while the bone infection may cause pain on biting, or may set up neuralgia.

If left alone the loosened teeth gradually drop out and, the gum healing, the patient is left cured but toothless. Before this happens many years elapse, during which the general health suffers from the chronic septic absorption. The muddy complexion, loss of strength, lassitude, even neuralgia, may all be traced to this cause. Some authorities hold that the large number of joint complaints now classed under the names of chronic osteo-arthritis and rheumatic gout are due to prolonged septic absorption, and that pyorrhœa alveolaris is a frequent source of such troubles. Occasionally the gums react differently to the irritation and become fibrous, while the periosteum lays down new bone on the outer side of the jaw below the level of the alveolus—a condition which may simulate a new growth.

Treatment.—The disease can be prevented by adopting the ordinary sanitary precautions of brushing all round the necks of the teeth with a stiff tooth-brush and an antiseptic tooth-powder twice every twenty-four hours, especially at night; but it is very difficult to cure when once established, for as long as there is decomposing material between the teeth and the gum the disease will progress.

Hydrogen peroxide is a useful agent, as it dislodges septic material from cavities to which access is not readily obtained; its usefulness is increased by the addition of carbolic lotion. Attention must be paid to the portions of the gum which lie between the teeth, and every effort made to evacuate and cleanse the sulcus round the teeth. Lately considerable success has attended the treatment of this disease by means of vaccines.

In many cases all the teeth affected have to be extracted before the condition is cured, and often this has left the patient edentulous. Before this is done, a radiograph should be taken to make sure that the condition is not due to a local abscess at the root of one tooth, as it has been found that extraction of this tooth will often allow the whole condition to clear up (C. Kempster).

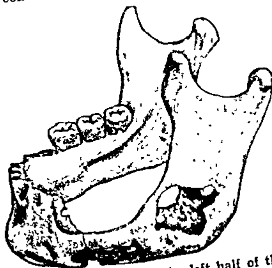


Fig. 758 —Necrosis of the left half of the lower jaw.

(*Specimen No 209, St Mary's Hospital Museum*)

NECROSIS OF THE JAW

As necrosis of the jaw nearly always starts as a periostitis, it is often the result of the inflammatory conditions dealt with in the preceding section. The lower jaw is more often and more severely attacked than the upper, for the inflammatory products can more easily find an exit from the cancellous bone of the latter than from the compact osseous tissue of the former. (Fig. 758) The upper jaw is also well supplied with vessels which freely anastomose, while the lower jaw has but two, and these hardly communicate with each other. The conditions upon which necrosis may ensue are:

1. Alveolar abscess, in which the inflammation spreads from the alveolo-dental membrane to the periosteum and the bone, causing death of a variable amount.

2. Injuries, especially fractures of the jaw, which, owing to the superficial position of the bone, are usually compound in character, and allow the entrance of organisms. These either set up a local necrosis or, extending into the medullary substance, determine the onset of an osteo-myelitis. The use of dirty instruments for the extraction of teeth may bring about the same result.

3. Necrosis occasionally arises during the course of one of the exanthemata, such as measles, scarlet fever, smallpox, or *typhoid*, or may follow these diseases in young people when the general health has been severely depressed. In these circumstances septic organisms circulating in the blood lodge in the medulla and set up an extensive osteo-myelitis, which causes the death of the whole jaw.

4. Syphilis may cause extensive necrosis in those who have contracted a virulent form of the disease. The superior maxilla, especially its palatine process, seems peculiarly liable to suffer, the destructive process extending to the soft palate and fauces. More rarely the disease leads to necrosis of the alveolus of the upper jaw, or of the compact tissue of the mandible. In cases of extensive tertiary ulceration of the face the bones may become secondarily involved.

5. Mercurial necrosis is rare at the present day, but formerly, when much larger doses were considered necessary, it was fairly common. The inhalation of the fumes of mercury in the old-fashioned process of manufacturing looking-glasses used to be a fruitful cause of necrosis. Salivation and a metallic taste in the mouth are the early symptoms, followed by soreness, looseness and falling out of the teeth, with exposure of the alveolar bone. It is hardly necessary to emphasize the *importance of attention to the condition of the mouth during the* administration of mercury. Carious teeth should be removed and a mouth-wash ordered as a routine procedure.

6. Phosphorus necrosis has practically disappeared with the substitution of amorphous for yellow phosphorus in the manufacture of matches. *It affects the* upper and the lower jaw equally. The fumes gain access to the bone through the carious teeth, set up an inflammatory reaction, with great swelling of the parts and rapid necrosis. Pus exudes along the sides of the loosened teeth, or from the sockets of those which have already dropped out, or it escapes externally through sinuses, in the depths of which bare bone can easily be felt. The general health suffers severely, and death may be caused by exhaustion. The sequestrum separates slowly, and has a curiously porous appearance, much resembling pumice-stone. A considerable formation of new bone takes place beneath the periosteum during the separation of the sequestrum.

7. Necrosis may be secondary to ulceration inside the mouth, such as cancrum oris. Recovery in these cases is extremely rare. A similar extension may be met with in scurvy and in rodent ulcer.

Symptoms.—Clinically many of the features of necrosis are the same, whatever the cause. There is pain in the jaw, increased on closing the teeth, and swelling of the gums and face. Great difficulty is experienced in opening the mouth and in taking food. The formation of pus is accompanied by severe general symptoms, such as

a marked rise of temperature, rigors, vomiting, and, in the case of children, convulsions. Abscesses form, and are either opened or burst, discharging their contents, with the formation of sinuses leading down to dead bone. In untreated cases the abscesses may burrow widely along the fascial planes of the neck. The teeth become loose and are shed from their dead sockets. The necrosis may affect part or the whole of one side from the condyle to the symphysis; occasionally both sides are involved.

Treatment should be directed towards the prevention of this condition in circumstances, such as fracture or periostitis, in which it is likely to ensue. When necrosis is suspected, free incisions should be made down to bone through the gums, and a free exit given to the pus, which might otherwise discharge through the skin. *Sepsis* should be diminished by the free use of antiseptic mouth-washes. As the patient cannot masticate, the food must be either fluid or prepared in a suitable manner, and every effort made to maintain the general health during the time which must elapse before the separation of the sequestrum. When the sequestrum is loose it should, if possible, be removed through the mouth. This, however, is not always possible in death of extensive portions of the lower jaw; here an external incision is required to open up the involucrum. The process of repair varies widely in the two jaws: the periosteum of the lower jaw shows great activity in re-forming the bone, so that even in severe cases little deformity ensues; while that of the upper jaw makes no attempt to restore the bone, the gap becoming filled with fibrous tissue which is usually firm enough to support a dental plate.

TUMOURS AND CYSTS IN CONNEXION WITH THE TEETH

Under this heading it is convenient to group together many swellings of the jaws which are believed to originate in various developmental embryonic tissues (*see also* Vol. I., p. 427). The classification of odontomes adopted by the Committee of the British Dental Association is

A. Epithelial odontomes.
  1. Dental cysts.
  2. Multilocular cystic tumour (epithelial odontome of Bland-Sutton, or fibro-cystic disease).
  3. Dentigerous cyst (follicular odontome).

B. Composite odontomes (including radicular odontome and composite follicular odontome of Bland-Sutton).

C. Connective-tissue odontomes.
  1. Fibrous odontomes.
  2. Cementomes.

A. Epithelial odontomes.

1. Dental cysts (Fig. 759) are not seldom found on extracting dead teeth of the permanent series, to the fangs of which they are firmly attached. They are met with, therefore, in people above middle age. Dental cysts are usually small, but may grow to large size, and cause a painless expansion of the bone, accompanied by parchment-like crackling They are commoner and attain their largest size in the upper jaw, where they grow into and simulate an abscess of the antrum, but are separated from that cavity by the cyst wall. They contain mucoid fluid, cholesterin crystals, and sometimes pus. The wall is chiefly fibrous, but the investigations of Malassez, Turner, and others have demonstrated the remains of an epithelial lining derived from the enamel organ. In old age, owing to the absorption of the teeth as well as of the sockets, the fang is the only part which continues in connexion with the cyst. These cysts differ from the next variety merely in being unilocular instead of multilocular.



Fig. 759.—Dental cysts at the roots of a dead lower molar.

(*Bland-Sutton's "Tumours"*)

2. Multilocular cystic disease (Fig. 760) of the jaw, like the preceding form, is derived from remnants of the enamel organ which have been stimulated into active growth by some unexplained cause. It is usually found about the twentieth year of life, and is more common in the lower than in the upper jaw, the relative incidence being in the proportion of 11 to 1. Microscopically, it consists of solid anastomosing rods of epithelial cells invading the fibrous and osseous tissue. (Fig. 761.) The outer cells remain cubical or columnar, while the inner ones degenerate; in this way cysts are formed, filled with cellular débris and mucoid fluid. These cysts, which are formed in large numbers, are small in size, and separated from each other by fibrous and osseous septa. The growing portion is reddish, and may be mistaken for myeloid tissue. The

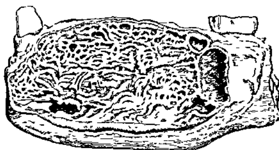


Fig 760.—Multilocular cystic disease. (*Natural size.*)

(*Bland Sutton's "Tumours."*)

growth gradually expands the bone in all directions. (Fig. 762.) It is liable to recur locally after removal, and may eventually take on malignant characters.

3. Dentigerous cysts.—The developing tooth grows by the activity of the cells of the dental papilla ; as growth proceeds, the papilla projects more and more into the dental sac with the walls of which its base is continuous. The dental sac is bounded by connective tissue, the inner layers being firm and regularly arranged, while the outer layers are loose and irregular. Before the tooth cuts the gum it is completely enclosed within this sac wall, through which it must force its way to reach the surface. In certain circumstances the tooth never cuts its way through, and secondary changes take place in the wall of the dental sac. The development of a follicular, a fibrous, or an osseous odontome depends on the extent to which these secondary changes proceed.

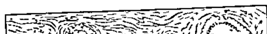


Fig. 761.—Microscopical characters of multilocular cystic disease.
(*Bland-Sutton's "Tumours"*)

In the simplest form, the *follicular* odontome, the wall of the dental sac forms a tough, vascular membrane lining the bone. The cavity becomes distended into a follicle, or cyst, which may attain large dimensions and create great deformity. Its contents are a viscid or glairy fluid, or even pus when suppuration has taken place. Attached to the wall is found the crown of the imprisoned and imperfectly developed ... in the

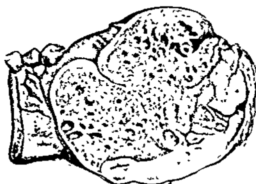


Fig. 762.—Part of a lower jaw expanded by multilocular cystic disease.
(*Specimen No. 389, St. Mary's Hospital Museum.*)

tooth ; ...

cavity. ...

permanent molars and affect both jaws, but are ... dible. (Fig. 763.) They may be mistaken for solid tumours of the bone.

B. **Composite odontomes** arise from the disordered growth of the whole tooth-germ, resulting in an irregular conglomeration of enamel, dentine, and cement substance, which bears no outward resemblance to a tooth. (Fig. 764.) As in compound follicular odontomes, more

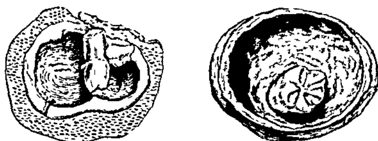


Fig. 763.—Follicular odontomes from the mandible.
(*Bland-Sutton's "Tumours"*)

than one tooth-germ may be involved, and in both cases all the dental elements are present. The chief difference between the compound follicular and the composite odontomes is that in the former the elements are arranged in a methodical manner, forming teeth, while in the latter they are present as a fused mass in which no attempt at dental formation can be recognized. The tumours may attain large size, especially in the maxilla. On account of their hardness they are sometimes mistaken for ivory exostoses. As a rule, they are noticed early in life as a swelling of the jaw in a situation where one or more teeth fail to erupt; their growth is slow. When the cavity in which they are contained is freely opened they can be easily removed, as they have no connexion with the surrounding bone; indeed, cases are on record in which ulceration has laid them bare, and they have actually dropped out of the cavity which contained them.

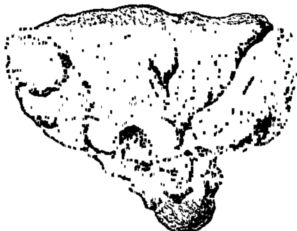


Fig. 764.—Composite odontome from upper jaw.
(*Bland-Sutton's "Tumours"*)

The compound follicular odontome (Bland-Sutton) results

when a disordered activity in the cells of the dental papillæ and the cells lining the distended dental sac produces a large number of very ill-formed teeth; as many as forty have been found in a single tumour. These tooth-like structures, or denticles, are found embedded in the fibrous and bony tissues of the cyst wall. When tumours of this nature occur in man it is not uncommon to find that more than one tooth has failed to erupt. This odontome probably arises, therefore, from the fusion of several adjacent dental sacs. This, according to the Dental Committee's classification, falls under the heading of composite odontomes.

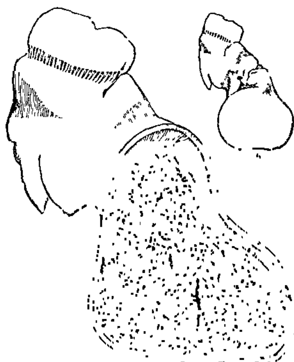


Fig 765.—Radicular odontome.
A, Natural size of specimen.
(*Bland-Sutton's "Tumours."*)

Radicular odontome (Fig. 765) is the name given to a rare tumour which falls under the classification of composite odontome. It develops in connexion with the tooth-fang some time after the formation of the enamel, as none of this substance is ever found in its composition. The tumour is composed of dentine and cementum in varying proportions, the latter enclosing the former. These growths are never of large size and usually are not diagnosed before an attempt is made to remove the tooth; the dental extraction necessarily involves fracture of a part of the alveolar process.

C. Connective-tissue odontomes.

1. **Fibrous odontomes** are rare in man, though common in some animals. In this formt he wall of the dental sac is formed of very dense, laminated, fibrous tissue which may be of great thickness. The cavity is small, being only just sufficient to enclose the unerupted tooth. Rickets is thought to have some influence on their formation, as they have been found chiefly in children suffering from that disease.

2. **Cementomes or osseous odontomes** are a further development in which calcification and ossification take place in the thickened wall of the dental sac, so that the tooth is embedded in a hard mass of cementum. Like the last variety, these are rare in man, though fairly common in horses.

The **diagnosis** between these forms of swelling is often difficult and sometimes impossible but may be facilitated if the following points are borne in mind: Cysts may resemble solid formations unless the expansion has thinned the bone sufficiently to allow indentation; but cysts expand the bone in all directions, whereas in periostitis and solid tumours only one side of the bone may be affected. The teeth must be examined to see if any are missing, and any milk teeth which may have persisted owing to lack of development of the corresponding tooth of the permanent set must be recognized as such. In many cases the X-rays will help the diagnosis by demonstrating a cavity, or sometimes a tooth, in the midst of the swelling.

A single cyst in connexion with a carious tooth of the permanent set is probably a dental cyst. If the swelling is solid, confined to the root of one tooth not necessarily carious, in an old person, it is probably a radicular odontome. If it is cyst-like, single and grows slowly in a young person, in the position of an unerupted tooth, it is a dentigerous cyst, and the consistence of its walls will serve to distinguish between the follicular, fibrous, and osseous varieties of this odontome If it is solid and occupies, in a young person, a situation in which two or more teeth have failed to erupt, it is either a compound follicular or a composite odontome If it started early in life, is multilocular, and has expanded the lower jaw in a lobulated manner, it is probably an epithelial odontome, and this diagnosis will be confirmed by local recurrence after operation.

Treatment.—For the want of better methods of diagnosis many operations of needless severity have been performed for these conditions All that is necessary is freely to open part of the bony wall and remove the growth if solid, or break down all septa and destroy the cell lining of the cavities if cystic. This is best done with the gouge, or sharp spoon, followed by the application of pure carbolic or zinc chloride (40 gr. to the ounce). The thin walls of the expanded bone are then crushed into apposition, and the cavity allowed to granulate. This procedure can usually be conducted from inside the mouth, but in the lower jaw an external incision under cover of the bone may have to be employed. In epithelial odontomes, especially when recurrence has taken place, partial or even complete resection of the mandible may be needed.

TUMOURS OF THE UPPER JAW

Simple tumours of the maxilla, apart from those connected with the teeth, are uncommon; fibromas, chondromas, and osteomas are but rarely seen, and need no special mention.

Leontiasis ossea is also a rare disease, which is sometimes referred to as hyperostosis of the jaws. It is a diffuse and usually symmetrical overgrowth of the facial and cranial bones, characterized by the formation of hyperostoses, which project as nodular outgrowths of hard, compact bone from the subcutaneous surfaces of the maxillæ, mandibles, and occasionally also from the bones of the head. Its development causes the patient to assume a most repulsive appearance. The tumours begin to be noticeable in early adult life, and grow slowly but gradually; the increase in size taking place internally as well as externally, so that there may be obliteration of cavities like the antrum and orbit, and serious encroachment upon the nasal and oral passages. Pressure on nerves may cause neuralgic symptoms, and even the mental faculties may suffer. The soft tissues over the tumours periodically become inflamed and painful. Most cases in the early stages show signs pointing to a chronic inflammation of the periosteum and the bone, but the cause of the condition is at present quite unknown. No evidence is forthcoming to support the opinion that it has any connexion with rickets, syphilis, or tuberculosis. The disease follows the ordinary course of innocent growths, interfering with function only by its size and position. The condition is not affected by any drugs, but where it is localized to one bone or to one side of the face its advance can be delayed, and sometimes permanently arrested, by operation.

Myeloid growths sometimes occur in the alveolar process of the maxilla, but are not so common as in the mandible. They are usually met with in young people, and the removal of a piece for microscopical examination is needed to clear up the diagnosis. Partial excision of the bone is necessary for their eradication.

Malignant growths *of the upper jaw are quite frequently* met with.

Sarcomas, either of the round- or of the spindle-celled variety, begin under the periosteum, in children or in people of advanced age. They usually arise in the anterior or posterior wall of the antrum and extend thence in one of the directions mentioned below. A considerable formation of bone usually takes place in these tumours, which may develop into solid bony masses. In advanced cases spread may take place to the opposite jaw, or the upper part of the ramus of the lower jaw may be invaded by a mass growing into the pterygoid fossa.

Carcinoma invades the bone secondarily from the soft parts. The common form starts as a squamous-celled growth in the gum or palate, but an acinous or columnar-celled growth may arise from the glandular structures of the nasal or antral cavities. Carcinoma and sarcoma resemble each other closely in their method of progress, so that their clinical features may be considered together; these differ according to the direction of spread. When arising from the anterior surface of the bone, the tumour projects under the cheek, which becomes prominent and, in the later stages, red, painful, and finally ulcerated. Growth takes place downwards, and is readily detected filling up the reflection of the mucous membrane from the cheek on to the jaw. The antrum may be invaded, but as the nose and palate are not encroached upon till late, nasal respiration is not obstructed, and there is no epiphora, nor is the roof of the mouth depressed.

If the growth commences within the antrum, it rapidly fills and distends that cavity, and occasions a foul and often blood-stained discharge from the corresponding nostril. The subjective phenomena are usually more severe than in the last case. The thin nasal wall of the antrum may bulge and impede respiration. Examination of the nose may reveal a fungating growth. The nasal duct is pressed upon, causing epiphora, and the palate becomes inflamed and depressed. In the case of an acinous cancer the name of boring or burrowing epithelioma (epithelioma terebrans) is sometimes applied, indicating the rapid infiltration of the surrounding tissues by this form of disease. When arising from the posterior surface of the bone, the tumour first grows into and fills up the spheno-maxillary fossa, and continues to grow by spreading in various directions. Most commonly it extends outwards into the pterygoid fossa, but may also grow inwards towards the naso-pharynx through the spheno-palatine foramen, upwards into the orbit by the pterygo-maxillary and sphenoidal fissures, or even downwards along the posterior palatine canal to invade the posterior part of the hard palate. The antrum may be invaded, or the maxilla as a whole may be displaced forwards by the tumour.

The *diagnosis* is made from a consideration of the symptoms and the nature of the growth. Pain is usually first complained of, and may be of a dull, boring nature felt locally, or of a sharp, shooting character due to pressure on some of the branches of the 5th nerve. A swelling is usually noticed over the region of the maxilla; this, together with the pain, has often led to the mistake of ascribing the trouble to toothache; no tumour, however, may appear if the growth starts inside the antrum. In these cases, careful examination must be made of the nasal cavity, palate, and alveolar process, and transillumination may be of the utmost value. The age of the patient,

the rapidity of growth, the invasion and vascularity of the surrounding tissues, and, in the case of carcinoma, the implication of the lymphatic glands, all help to distinguish it from an innocent growth. An exploratory incision should be undertaken and a piece removed for microscopical examination in all cases where doubt exists.

Treatment consists in removing the growth widely as soon as its true nature has been recognized. This nearly always implies complete excision of the superior maxilla, and, where the tissues of the cheek are implicated, freedom from recurrence can only be obtained at the expense of considerable mutilation and risk to the life of the patient. Eradication of growths springing from the posterior aspect of the maxilla is always a hazardous procedure, and the danger should be fully explained beforehand to the patient. The actual details of operation differ with the requirements of each case, and for them the reader must be referred to works on operative surgery. As a rule, patients stand the operation remarkably well. Healing takes place rapidly, leaving of course a deficiency in the palate; this, however, can be closed later by a plate fashioned so as to shut off the nose and at the same time fill out the sunken cheek. The deformity which ensues on this operation, though noticeable, is less than might be expected, and is further diminished when the floor of the orbit can be left in position to support the eye and maintain the fullness of the cheek.

More limited operations can sometimes be performed, such as taking away the alveolar process, or even excising the upper part of the bone and leaving the alveolar margin in place. These cases are, however, rare; the chief aim of the surgeon, the complete extirpation of the disease, should never be sacrificed to a regard for appearances.

TUMOURS OF THE LOWER JAW

As in the case of the upper jaw, such **simple** tumours as chondroma, osteoma, and fibroma are rarely seen; polypus, epulis, and tumours in relation to the teeth have already been described.

Myeloid tumours develop far more frequently in the lower than in the upper jaw; allusion has already been made to their association with certain forms of epulis. The body of the bone is the part most usually affected, and the clinical features are, as a rule, sufficiently distinctive to ensure accurate diagnosis. Nearly always the patients are young adults. As the tumour grows it slowly absorbs and expands the bone so that a characteristic crackling sensation can sometimes be felt on pressure. If the osseous shell is perforated, pulsation may be noticed in the protruding myelomatous tissue. No secondary growths appear either in the glands or in other viscera.

In dealing with the tumour the bony shell is freely opened and all the myelomatous tissue scraped from its interior, which is then swabbed out with pure carbolic acid or zinc chloride and packed with gauze dipped in one of these fluids. Should there be recurrence a partial excision of the jaw may become necessary. Where possible, an osseous bridge should always be left to keep the two fragments of the bone apart and to preserve the line of the jaw; if this is impossible a metal splint should be introduced to achieve the same object.

Among **malignant** tumours, **sarcomas**, both round- and spindle-celled, occasionally arise in the periosteum of the bone. They grow rapidly and are very vascular as a whole, although the deeper parts become ossified. The clinical history is typical of a malignant growth, and early excision of the affected part is needed to extirpate the disease.

Epithelioma is commoner in the lower jaw than is sarcoma. It begins as an ulcer confined to the lips, gums, or tongue, which later becomes adherent to the bone and finally invades its substance. Wide excision of the ulcer together with the affected piece of bone and the neighbouring lymphatic glands is the only possible treatment. A certain amount of deformity as the result of excision of the lower jaw is unavoidable.

DISEASES OF THE TEMPORO-MANDIBULAR ARTICULATION

Acute arthritis sometimes results from infection by organisms circulating in the blood during rheumatic fever, gonorrhœa, or suppurative infections. In children direct infection is said to take place through a defect in the floor of the middle ear, but this must be very rare. Acute pain is experienced on attempting to open or move the jaws; there is tenderness over the joint, and the tissues around are red and swollen. The rheumatic form readily subsides under treatment, the gonorrhœal form is more difficult to cure and is likely to persist until the source of infection in the urethra and prostate has cleared up Suppuration does not occur, but adhesions are very apt to form and give trouble later. When the joint is invaded by pus-forming organisms, however, suppuration quickly ensues and the joint must be opened, washed out and freely drained, to prevent the abscesses from burrowing into the surrounding tissues. Should ankylosis take place, excision of the condyle will be required later.

Chronic arthritis of the nature of arthritis deformans is not uncommon in this joint after middle life; usually it is symmetrical, and evidence of the same disease can be found in other joints. The condyle becomes enlarged, flattened and eburnated, the cartilage is destroyed, and the interarticular meniscus disappears; the eminentia

articularis becomes less marked, allowing the condyle to come farther forward and the chin to project more than formerly; when only one side is affected *the point of the chin is directed to the sound side.* Pain and creaking are noticed, though both these become less after brisk movements; the pain varies with the weather. In bad cases the disease *may progress to such an extent that food can no longer be* masticated. In the early stages ordinary medical treatment with courses of spa waters may do good; in the later stages excision of the condyle may be needed: this operation gives excellent results.

Tuberculous disease of this joint is rare and requires no special notice. Caries causes destruction of the head of the bone. As the jaw cannot be kept at rest, early operation is required to clear out the disease and prevent the formation of abscesses or the advent of a mixed infection.

FIXITY OF THE JAW (TRISMUS)

Inability to open the mouth may be due to a great variety of causes.

1. Fibrous or osseous ankylosis may result from infection of the articulation by the organisms of gonorrhœa, pneumonia, tuberculosis, typhoid, or of other acute suppurative conditions.

2. The development of new bone may greatly impede the movement of the jaw, even without ankylosis, in osteo-arthritis, necrosis of the jaw, fractures of the neck of the bone, old-standing dislocations, or in tumour- or *cyst-formation.*

3. Cicatricial contraction or ossification of structures round the joint, either inside or outside the mouth, from burns, lupus, cancrum oris, necrosis, or scars of extensive operations in the neighbourhood, or in myositis ossificans.

4. Spasms of muscles due to the reflex irritation from local conditions, such as infections of the joint, carious teeth, or an impacted wisdom-tooth. Spasms may be hysterical in nature. In tetanus the spasms are always preceded or accompanied by spasms of the muscles of the back of the neck and of the face.

5. Acute inflammatory conditions may, by their pain, prevent the free mobility of the articulation; among the commoner of these which occur externally are acute parotitis, lymphadenitis in the neck, angina Ludovici; while inside the mouth acute *tonsillitis,* stomatitis, periostitis, and epithelioma may all produce the same result.

Treatment *of the conditions under the last two headings* (4, 5) depends on the cause, which must be carefully ascertained in each case; as this subsides under appropriate treatment the mobility of the jaw is recovered.

Cicatricial contraction, however, is more difficult to relieve, and the difficulty increases with the depth to which the scar tissue extends. Simple division of the scar inside or outside the mouth is quite useless, and only aggravates the condition by creating more fibrous tissue. In the milder cases excision of the scar, combined with some form of plastic operation and systematic stretching of the muscles, may be sufficient; but when the muscles are destroyed and replaced by fibrous tissue it is hopeless to expect a satisfactory result by anything short of the removal of a wedge-shaped piece of bone. In Esmarch's operation a wedge is removed from the angle of the jaw, the apex of the wedge being at the alveolar margin, and the remains of the muscles are freed from the bone beyond the section. Stitching the muscles in between the two osseous surfaces prevents bony union and favours the development of a false joint. Removal of most of the ascending ramus above the level of the alveolus is another method of restoring movement which the author has proved to be successful.

Excision of the head of the bone is needed when fibrous ankylosis has taken place. The operation is not always easy, as the space at the disposal of the surgeon is limited by the facial nerve below, the parotid gland in front, and the ear behind A curved incision is made running along the lower margin of the posterior part of the zygoma, and then turning downwards to the lobule of the ear. The flap thus marked out is turned forwards and the fascia divided horizontally so as to expose the neck of the jaw, which is divided by the saw and cutting forceps. The head of the bone is then twisted out, and the wound closed after all the bleeding-points have been secured.

If there is extensive osseous union between the condyle and the glenoid cavity of the temporal bone, and attempts are made to separate the two by means of the chisel, there is considerable risk of injuring the floor of the middle ear or of opening into the middle fossa of the skull, both of which cavities are only separated from the field of operation by a thin plate of bone. In such cases it is advisable to remove the neck and as much of the ramus as can be conveniently reached, and to interpose muscular tissue between the two bony surfaces to ensure the formation of a false joint. In all cases of fixity of the jaw where operative methods have been resorted to, a course of systematic movements is absolutely necessary if the result is to be of permanent benefit.

THE SKIN AND SUBCUTANEOUS TISSUES

BY T. P. LEGG, C.M.G., M.S., F.R.C.S.

INFLAMMATORY AFFECTIONS

BOILS AND CARBUNCLES

A **boil** (furuncle) is a localized acute inflammation due to invasion of a hair-follicle by the *Staphylococcus pyogenes aureus*; it terminates in the formation of a central slough, surrounded by a layer of pus, outside which is a zone of granulation tissue.

Clinical signs.—A boil begins as a small red papule, from the centre of which a hair may protrude In the centre of the papule a small collection of pus appears as a yellow spot. The pain and itching increase, and tenderness may be great because the pus is retained under tension by the epidermis on the surface. The skin and underlying tissues become œdematous, and sooner or later the pus is discharged, leaving the yellow central slough or core, which is either extruded spontaneously or removed. The skin is often undermined for some distance; the resultant cavity heals by granulation. The size of the scar depends on the amount of skin destruction, and very often is quite imperceptible. The lymphatic glands draining the affected area may be enlarged, painful, and tender. Sometimes suppuration does not take place; a *blind boil* is then formed. The constitutional effects of a boil vary; the patient often feels unwell, and a furuncle on the ala nasi or the tip of the nose, for instance, may produce very severe symptoms and considerable fever. In places where the connective tissue is loose the œdema may be widespread. Boils are often multiple.

Secondary boils frequently surround the primary furuncle; these are due to auto-inoculation of the hair-follicles from friction of the clothes or the application of remedies such as boric fomentations that keep the skin moist and sodden.

Pathology.—The essential cause is the entrance of staphylococci through a hair-follicle into the surrounding cellular tissue; there they multiply and cause acute inflammatory changes which result

in the formation of a papule, the rate of enlargement varying with the virulence of the organisms. Microbial invasion is especially likely in places subject to friction and the chafing of the clothes; hence boils are most common on the back of the neck and on the buttock—regions abundantly supplied with hair-follicles and where the epidermis is thick. Another important factor is the general state of the patient's health; this is often below normal, either on account of insanitary surroundings, insufficient or improper diet, or the debility which follows prolonged illnesses such as typhoid fever. It is also possible that toxæmia from intestinal disorders, and sometimes diabetes mellitus, may be factors in the causation of boils. Rowing men are peculiarly liable to gluteal boils, probably due to friction.

A **carbuncle** is a more or less extensive sloughing of the skin and subcutaneous tissues. It may be regarded as a collection of boils which have become confluent, and consequently it presents several openings on the surface, through which the sloughs and pus are discharged.

Clinical signs.—A carbuncle begins as a painful swelling or induration in the subcutaneous tissue. The skin soon becomes reddened, and the swelling gradually or rapidly increases in size until an area of several square inches may be involved. The surrounding tissues are œdematous and the skin is destroyed; several openings are formed, through which the pus is discharged and the yellowish-white necrotic tissues are visible. At first the slough is closely adherent, and attempts to detach it are exceedingly painful and usually ineffective. At the onset the pain is often very severe, but is relieved after the skin has been destroyed, especially if it has sloughed over a large area. As a rule, a carbuncle is single. The constitutional disturbance is often considerable; the appetite is lost, the tongue is furred, the bowels are constipated, and the temperature is generally raised several degrees, though in the worst cases it may be normal or even subnormal.

Pathology.—The entrance of virulent organisms, such as the *Staphylococcus pyogenes aureus*, into the subcutaneous tissue leads to an acute inflammatory reaction which is of such an intense degree that the tissues necrose The blood-vessels are filled with infective thrombi, and there is thus a risk of pyæmic developments.

Carbuncles are most common in people who have undergone general privation. They may follow an acute illness, or be associated with renal disease, and sometimes with diabetes mellitus. Glycosuria may be present during the acute stages of the disease, apart from diabetes, but disappears as recovery takes place The patients may be young, but are usually getting on in years The commonest sites are the nape of the neck, the shoulders, and the back; sometimes carbuncle occurs on the limbs.

The amount of destruction of the tissues depends (1) on the virulence of the organism, (2) on the general health of the patient, (3) on the time at which efficient treatment is adopted.

Differential diagnosis.—A *subcuticular whitlow* is distinguished from a boil by the fact that in this affection the epidermis only is raised by a collection of pus from the underlying tissue. It occurs on the finger, and secondarily to a slight injury such as a prick from a needle. The surrounding skin shows a zone of redness extending for some distance. There is no central slough or yellow spot. An *acute subcutaneous abscess* may simulate a carbuncle, but there is not the same degree of induration, and the central parts are soft and fluctuating while the periphery is hard. The skin over the swelling is intact and œdematous. Hæmorrhage into the abscess from rupture of some of the blood-vessels may cause the skin to be coloured a deep red, and thus the superficial resemblance to a carbuncle is increased; pressure, however, does not cause the colour to disappear when it is due to extravasation of blood. *Malignant pustule* (cutaneous anthrax) is diagnosed from a carbuncle by the presence of a central black slough surrounded by a brawny, indurated swelling, frequently there is a secondary ring of vesicles around the slough. Pus-formation is absent, and in the fluid obtained from beneath the slough the characteristic anthrax bacilli may be demonstrated. Moreover, the occupation of the patient, if involving handling of infected hides or animals, may suggest the diagnosis. *Gummata* secondarily infected with pyogenetic organisms may occasionally give rise to difficulty in diagnosis.

Prognosis.—This is good in the case of **boils**, but the liability to recurrences extending over a long period of time must not be forgotten, nor the fact that a boil may be the starting-point of severe cellulitis or erysipelas. The prognosis in a case of **carbuncle** depends largely on the constitutional state of the patient. If he is afflicted with diabetes or renal disease, or is suffering from prolonged starvation or chronic alcoholism, a fatal termination through exhaustion or toxæmia may occur; in diabetes the patient often succumbs to coma. Carbuncles and boils on the face and lips are especially dangerous, as infective thrombosis of the superficial veins may occur, and on account of their free communications with the deep veins the process may quickly spread to the cranial sinuses, especially the cavernous Acute septicæmia or pyæmia may develop, and lead to a fatal termination in a few days

Treatment. **Boils.**—The skin surrounding the boil must be thoroughly disinfected, the boil protected from pressure and friction, the pus evacuated, and constitutional treatment adopted. The skin is disinfected by washing with hot water and ether soap, followed by

1 : 2,000 perchloride-of-mercury lotion, or a compress of the same antiseptic may be applied. Linseed-meal and bread poultices should be avoided; hot fomentations, frequently renewed, may be used, provided a fresh piece of lint or gauze is applied each time the fomentation is changed; but, owing to their warmth and moisture, they have the disadvantage that, unless strongly antiseptic and therefore probably irritant and even destructive, they tend to encourage auto-inoculation of neighbouring hair-follicles. Pressure and friction are avoided by rearrangement of the clothing and by covering the boi with a collodion dressing or other form of shield. When suppuration has occurred the pus should be freely evacuated by transfixing the boil with a sharp knife, making a crucial incision, and if the slough is loose it should be removed by forceps. When the skin is much undermined a small piece of gauze, soaked in an antiseptic, should be placed in the cavity, and changed as often as necessary. It is inadvisable to incise a boil before pus is present.

Bier's suction method may be used both in the early stages and after the pus has been evacuated.

Constitutional treatment consists in administering general tonics, such as quinine and iron, ensuring a regular daily evacuation of the bowels, and giving a generous diet. Dilute sulphuric acid (10–20 min.) and sulphur are sometimes useful in both acute and chronic cases. Change of air to the seaside is often beneficial. To raise the patient's powers of resistance to the invasion of the staphylococcus, a vaccine of this organism may be administered once a week, an initial dose of 250 to 500 millions being given. (For details, *see* Vol. I., p. 125.) Intramuscular injections of colloidal manganese are beneficial in some cases. The initial dose should be 0 5 c c.; a second dose of the same amount may be given in three days' time, and 1 c.c. at the end of another three days. "Stannoxyl" tablets may also be tried.

Carbuncles.—In the first place the general health of the patient must be improved, hence easily digestible, nourishing food, stimulants, and tonics will be required. If the patient is suffering from diabetes, the treatment appropriate to that affection should be instituted. Codeine (gr. ½) may be given three times a day. Opium or morphia may be administered to relieve pain and give sleep. Tincture of the perchloride of iron in doses of 15–20 min., three times a day, is one of the best tonics.

The injection of a staphylococcic vaccine, autogenous if possible (500 millions for an initial dose), is strongly recommended on the ground that it tends to shorten the inflammatory and necrotic processes, and thus to hinder the extension of the disease. Colloidal manganese may also be tried.

Local treatment is either palliative or radical. The former con-

sists in the frequent application of hot fomentations. Radical treatment is generally necessary, either by free excision, by incision, or by incision combined with scraping.

Excision is the best treatment whenever possible. It is suitable for carbuncles of moderate size, and when there is no general constitutional state contra-indicating its employment. The incisions must be made wide of the necrosed area so as to remove the whole of it; they must be carried down to the deep fascia, otherwise extension of the affection is certain to occur. Hæmorrhage is generally easily arrested by pressure with gauze, but one or two vessels may require ligature. The wound is packed with gauze soaked in an antiseptic lotion, and is allowed to heal by granulation. Skin-grafting may be employed to hasten the healing when the raw area is covered with clean granulations.

Incisions combined with scraping to remove the sloughs and necrotic tissue may be employed when excision is not feasible. The incisions should be long—short ones are useless. The sloughs, which may be very adherent, should be removed as thoroughly as possible. The infected edges of the carbuncle remain, from which extension of the disease may take place. There is said to be a liability to detach infected thrombi and thus set up pyæmia; but probably this risk has been exaggerated. The cavity and the incisions are lightly packed with gauze wrung out of perchloride of mercury (1 : 2,000), changed once or twice daily. Rubber drains are useful, and to prevent the gauze adhering to the inflamed tissues a thin piece of rubber tissue may be laid in the incisions, and the gauze placed on the surface of this. Hot fomentations may be applied over the gauze and adjacent skin. Peroxide of hydrogen (10–20 volumes) is sometimes useful to loosen the sloughs.

Simple crucial incision.—This is the least radical method of treatment. It is useful in relieving pain and tension, and in allowing the liquefied portion of tissues to escape. But the septic process is not checked, the necrosed parts are not removed and take a long time to separate. Therefore this method should be employed only when the patient is so ill that it would be dangerous to adopt one of the other methods or to give a general anæsthetic. The use of gas and oxygen has, however, greatly reduced this risk.

WHITLOW

A whitlow is an acute inflammatory condition involving a finger, and usually proceeding to suppuration. The term includes several distinct varieties, viz.:

1. Ungual whitlow or onychia (*see* p. 688).
2. Subcuticular whitlow, often affecting the pulp of a *finger-tip*

The epidermis is raised from the underlying tissues by inflammatory exudate that becomes purulent. Treatment calls for congestion by Bier's method and early incision for the relief of tension and the evacuation of pus.

3. Thecal whitlow, involving the tendon sheaths (*see* p. 708).

4 Phalangeal whitlow, in which, as a result of extension of infection from one of the other varieties of whitlow, a phalanx, usually a terminal one, becomes necrosed. This complication should be prevented by early and thorough incision of the infected soft tissues. If necrosis has occurred, excision of the affected bone, or even amputation, will be required.

ACUTE ABSCESSES OF THE SKIN AND SUBCUTANEOUS TISSUE

These abscesses are not infrequent; they are more common in children than in adults, and may be single or multiple. One portion of the skin is infected from another by scratching or by the dirty condition of the clothes. The organisms present are most frequently a staphylococcus (aureus) or the pneumococcus.

Treatment consists in evacuating the pus and applying an antiseptic dressing, such as gauze wrung out of a 1 : 2,000 perchloride-of-mercury solution. The skin should be cleansed with soap and water. Clean garments should be substituted for dirty ones. A course of autogenous vaccines may be advisable (*see* Vol. I., pp. 125–27).

ERYSIPELAS

Although erysipelas may attack mucous membranes and is not essentially a disease of skin and subcutaneous tissues, it may conveniently be considered here.

For long believed to be a specific infection with the streptococcus erysipelatosus, it is now generally recognized that erysipelas is commonly attributable to an organism fundamentally identical with streptococcus pyogenes, and that the special clinical manifestations are due to the accidents of the relative virulence of the strain of microbe and of the method and locality of attack. Occasionally, even, erysipelatoid symptoms may be induced by organisms not belonging to the streptococcal group at all

Etiology.—The exciting cause is an infection of the skin with cocci, practically always a streptococcus pyogenes. They effect an entry through a wound or scratch, especially one already infected with pyogenetic organisms; in the "idiopathic" variety formerly described, closer observation would probably always have revealed the presence of some minute superficial puncture. The predisposing causes are any factors that induce lowering of resistance;

among these are faulty personal and domestic hygiene, alcoholism, gout, diabetes, arterial and renal disease, and exposure to extremes of weather. Once contracted, the disease tends to recur.

Clinical features.—*After* some hours of slight fever, malaise, headache, and chilliness, a bright-red rash with palpably raised edges appears near the site of infection, and thence spreads centrifugally, the central parts tending to fade as the affected area widens. There is a sense of stiffness and burning, which in denser parts, such as the scalp, becomes a definite pain. The bright colour fades on pressure, but reappears on release.

The eyelids, scrotum, and other lax parts may show considerable œdema.

Vesiculation is common near the edge, followed by a fine desquamation on the older parts; pustulation and suppuration are rare.

The attacking cocci are especially found in the smaller lymphatics, just beyond the obvious edge. There may be associated lymphangitis, running towards the nearest glands, which are themselves enlarged, tender and painful from an early date.

The rash may spread on to mucous membranes, and in the mouth and throat may lead to dyspnœa and dysphagia. The wound of infection, meantime, may have healed, and then often opens again, presenting greyish or yellowish surfaces with feeble signs of reaction; in other cases it is "septic" from the first.

An attack of erysipelas supervening in a chronically infected, syphilitic, or tuberculous wound or ulcer sometimes greatly hastens the cure of the primary infection. A similar result is occasionally seen in sarcoma—an observation upon which is based Coley's method of treatment of sarcoma.

The *general symptoms* vary within wide limits: in some cases they merely consist of slight fever and malaise; but often the temperature persists between 101° and 104° F., the patient is obviously ill, has a full, bounding pulse, and suffers from a busy, noisy delirium, especially marked in cephalic cases.

When exhaustion supervenes the pulse becomes small and rapid, and the delirium quiet and muttering.

The clinical features of erysipelas vary somewhat with the locality of attack; thus in the *scrotum* redness and sharp delimitation of edge are obscured by the relative excess of watery œdema, which may even suggest the presence of "extravasation of urine." In the *mouth and throat* erysipelas is a dangerous complaint, owing to the possibility of glottic swelling. The soft palate, tongue, fauces, and glottic region may be bright red and very swollen; later they may necrose. The associated asthenia may be serious. The *face* is especially liable to seasonally recurrent attacks of "idiopathic" erysipelas.

Although it causes a bloated appearance and burning, stiff sensation, the prognosis is usually good unless the condition spreads into the mouth and throat or on to the scalp.

In infants erysipelas sometimes affects the skin around the umbilicus during or after the separation of the cord. Gangrene of the skin may occur, and death from septicæmia is not unlikely.

In the so-called phlegmonous or gangrenous erysipelas there is, in addition to the inflammation of the skin, suppuration in the subcutaneous tissues or a diffuse cellulitis; there may be sloughing of these tissues, and the constitutional symptoms are much more severe. It is not improbable that in these cases there is a mixed infection.

Prognosis.—After a period varying from five days to about four weeks the condition often resolves and the patient recovers, although he may remain subject to relapses and recurrences. Occasionally in feeble people a virulent attack may cause local necrosis of the skin: or, again, pyæmia, nephritis, meningitis, pleurisy, or malignant endocarditis may be superadded and materially diminish the chances of recovery. Erysipelas *per se* has a low mortality, except in old people, babies, and those debilitated by alcoholism, diabetes, or renal disease.

The **diagnosis** is usually easy; the sharply defined, palpable edge, the bright-red colour (especially near the margins), the vesicles, which, though perhaps very fine, are almost always present, the enlargement of neighbouring glands, and the general symptoms, which are usually pronounced, will, as a rule, render the clinical picture sufficiently clear. *Subjacent abscess-formation* or *cellulitis* does not show the sharp edge or the vesiculation. The rash associated with local irritation due to *iodoform* (in persons with an idiosyncrasy to this drug) may be bright red and vesiculated, but remains most acute near the primary focus; moreover, general symptoms, if present, include an iodoform taste in the mouth, gastro-intestinal disturbance, and a delirium which is of a depressed character from the beginning. *Erythema nodosum* is found especially in young women, often shows discrete very tender patches, and causes slight general symptoms. *Simple erythema* and the erythema which follows exposure to the sun, especially when the face is the affected part, may cause some difficulty in diagnosis. In these cases there are no constitutional symptoms, the edge of the inflamed part is not raised, and the lymphatic glands are not enlarged. The *bites of insects*, especially when they occur on the face, eyelids, or scrotum, may at first sight simulate erysipelas, but a careful examination for the central puncture is usually enough to enable a correct diagnosis to be reached The *use of iodine* for the disinfection of the skin preparatory to an operation may be followed by an intense erythematous

rash with vesicle-formation, especially if double cyanide gauze is used as a dressing. The resemblance to erysipelas is very close; constitutional symptoms are, however, absent.

Treatment.—As the disease does not occur in an aseptic wound, the first point in treatment is to secure asepsis in all wounds. A case of erysipelas is not dangerous to other people, provided that *strict asepsis and antisepsis are observed*; nevertheless, when a case occurs in a surgical ward the patient should be isolated. Gloves should be worn while the dressings are changed. All instruments and other utensils should be sterilized by boiling, dressings burnt after use, and the bed and linen disinfected at the end of the case.

General treatment.—At the outset a saline purgative or calomel should be administered, and repeated to obtain a daily evacuation of the bowels. The diet should consist of milk, beef-tea, eggs, and milk puddings while the acute symptoms persist. Stimulants should be given as required. Tincture of perchloride of iron (10–30 min.) every three or four hours is by some considered to be specific, and quinine is also useful. These drugs may be given in combination in a mixture.

Antistreptococcic serum is often employed, sometimes with benefit. An initial dose of 20 c c may be given, followed by another of 10 c c. in twelve hours, and a third of 10 c c. after another twelve hours. If the serum is thought to be doing good a dose of 10 c.c. may be given twice daily A vaccine prepared from the streptococcus may be used, beginning with a small number (10 millions), and repeating the dose according to the clinical effects produced (*see* Vol. I, p 126).

Local treatment.—Many and various local applications have been employed and their good effects much vaunted; but on account of the tendency to spontaneous recovery it is not easy to say how *much benefit is due to the application itself.* To relieve the pain and discomfort, hot fomentations, or lint constantly soaked in lead-and-opium lotion, may be used. Sometimes the application of a dusting powder of oxide of zinc and starch, or of a paste consisting of carbolic acid (1 : 20) and pulv. cretæ aromat., will relieve the tingling and smarting, the affected area being also covered with a layer of warm cotton-wool. Dilute carbolic-acid lotion or spraying the part with carbolic acid is also said to be beneficial. *Ichthyol* solution (10–25 per cent. in glycerine) may be painted over the inflamed area two or three times a day till the inflammation subsides.

Various plans have been adopted to produce a barrier of leucocytes in the tissues beyond the limits of the affected area, and so to check the spread of the inflammation. These methods may be useful if they are employed thoroughly. Solid silver-nitrate or liniment of iodine may be applied to the skin at a distance of about an inch all

around the inflamed part. Kraske's method consists in scarifying the skin just deeply enough to draw blood. The scarifications should be very numerous and cross one another; they surround the affected area at a distance of 1–2 in. from the edge. An anæsthetic is necessary, and, after the oozing has stopped, compresses wrung out of 1 : 40 carbolic-acid lotion are applied and frequently changed. This method is only necessary in severe and spreading cases.

In phlegmonous or gangrenous erysipelas free incisions will be required, the wounds being kept open by means of gauze plugs or rubber tissue lightly packed into them.

During the desquamative process which follows the subsidence of the inflammation the part should be kept covered with a weak antiseptic ointment, such as unguentum acidi carbolici dilutum.

CELLULITIS

An infection of the cellular tissues by pyogenetic organisms, usually leading to the formation of pus, and not uncommonly to sloughing of the tissues. Only that variety which affects the subcutaneous tissues will be discussed here In the past the disease was designated cellulo-cutaneous erysipelas, the chief distinction from erysipelas being that suppuration, sloughing, and gangrene occurred frequently in this condition and were rare in erysipelas. Nowadays these cases are called cellulitis.

Etiology.—The essential cause is the entrance of micro-organisms. The wound of entry may be a minute insect-bite, prick, or puncture, a large laceration, or an operation incision. The streptococcus pyogenes is most frequently present, but staphylococci and other organisms may be the cause of the disease.

Symptoms.—The *constitutional symptoms* are often severe Repeated rigors may occur, the temperature is raised, the frequency of the pulse increased, and the tongue furred. Delirium and sleeplessness are not uncommon.

The *local symptoms* depend on the virulence of the organism, and may be anything from a slight redness, extending for some distance from the point of entry, to a widespread suppuration. Pain is usually severe and of a throbbing character; it begins after a longer or shorter interval from the time of infection, and *pari passu* the affected part becomes red, tender, and swollen as well as hotter than the normal skin. Local hæmorrhagic spots are not uncommon, and sometimes a diffuse extravasation of blood may be present. As the inflammation develops the skin becomes œdematous, brawny, and tense. Suppuration occurs, but, as the pus is diffused, fluctuation is not necessarily present. But if the disease is allowed to progress untreated, definite collections of pus may be formed and the skin be raised from

the deep fascia over a wide area. Red streaks in the skin, indicating the spread of the infection along the lymphatics, are seen extending towards the lymphatic glands, and localized abscesses are not infrequent in the paths of the lymphatic vessels. The fat and cellular tissues become swollen and infiltrated with serous fluid or thin pus; the blood-vessels are engorged and dilated, and hence when incisions are made into the inflamed area very free hæmorrhage ensues. Widespread sloughing of the cellular tissues and of the skin may occur, and death from septicæmia or pyæmia may follow. Extension of infection through the deep fascia sometimes, though rarely, takes place

Cellulitis of the *scalp* is generally due to a septic wound which has penetrated the occipito-frontalis or its aponeurosis. The inflammation involves the loose layer of tissue beneath that muscle, and the whole scalp may be raised by a collection of pus beneath the aponeurosis; the *attachments of the occipito-frontalis in front* and behind, and of the aponeurosis at the sides of the head, serve to limit the extent of the suppuration Suppuration in this locality presents *a special danger of intracranial complications owing to the free venous* communication through the skull. In some cases the cellulitis is superficial to the aponeurosis, in the dense connective-tissue layer *beneath the skin; in this case the suppuration is much more localized* and the scalp is tender, red, and œdematous.

Cellulitis of the *neck* (Ludwig's angina) is described elsewhere *(see* Vol. *I*, p. *222)*.

Treatment.—Local treatment is first prophylactic, and consists in the thorough disinfection of accidental wounds and of the surrounding skin. As soon as any redness develops, *hot fomentations* should be applied and absolute rest to the part enjoined. Bier's method of congestion may also be employed. If these means do not arrest the inflammation a general anæsthetic must be given, the original wound opened up and disinfected, and free incisions (2 in. or more in length) made into the inflamed area parallel to the main vessels and extending to the deep fascia, or deeper if required. The incisions should be allowed to bleed freely, and the tissues should not be stripped off the deep fascia and skin. Sterilized gauze soaked in an antiseptic, or rubber tissue, is lightly plugged into each wound, and hot fomentations or wet dressings are applied. The dressings must be frequently changed, and it is a good plan to place the part, whenever possible, in a bath of antiseptic lotion such as eusol, boric acid, or of sterilized water to each pint of which l [illegible] The temperature of the bath sho [illegible] be frequently changed, and the [illegible] ime to time during and

after use. Constant irrigation with similar solutions, or with eusol or Dakin's solution, is also useful.

Antistreptococcic serum—or, better, an autogenous vaccine—may be used as an adjunct to the foregoing methods of treatment.

During the stage of recovery, attention must be paid to the position of the part, to regulate contractions. When the inflammation has subsided, active and passive movements as well as massage will be necessary to prevent stiffness, and elastic bandages to prevent œdema.

General treatment.—The patient's strength must be maintained by a generous and easily digested diet. Brandy or champagne is generally indicated as a stimulant in debilitated persons, and strychnine hypodermically may be required.

In cellulitis of the scalp the whole scalp must be shaved and incisions made parallel to the main blood-vessels; light gauze packing, rubber tissue, or drainage-tubes may be passed from one incision to the other.

CHILBLAIN (ERYTHEMA PERNIO)

In this affection there is a localized or diffused hyperæmia of the skin In the localized form a swelling appears beneath the skin, which becomes red, œdematous, and shining. Exudation may occur beneath the epidermis, forming a vesicle which may burst, giving rise to an ulcer; and this may slowly spread, or heal with difficulty. Instead of vesicles, cracks and fissures may be produced. The diffuse variety often accompanies the localized form, and causes an œdema and redness of the whole or part of the affected finger or toe, cracks and fissures being a not infrequent accompaniment

Symptoms.—The affected part begins to itch and burn, and becomes very tender; movements are often exceedingly painful. The fingers, toes, heels, and ears are the commonest sites; they become blue, cold, and swollen from congestion.

Pathology.—The onset of chilblains is determined by exposure to cold, perhaps of slight degree They usually occur in persons with defective circulation and cold extremities. An important factor would appear to be a diminished power of coagulation of the blood.

Treatment.—Remedies which improve the circulation must be administered, the exposed parts should be warmly and loosely clad Calcium lactate (10-15 gr. thrice daily) may be administered, and cod-liver oil and malt may be useful. When ulceration occurs the part must be dressed daily with a mild antiseptic; lint or gauze soaked in tinct benzoini co. is sometimes useful.

A weak galvanic current (5 ma. daily for ten minutes, the positive pole being placed in a basin of water in which the hands are

immersed and the negative pole on the cervical spine) often leads to considerable improvement. If the feet are being treated, the negative pole is placed on the lumbar spine.

TUBERCULOUS DISEASES OF THE SKIN

Tuberculosis of the skin occurs in the form of lupus, of verruca necrogenica (*see* p. 665), and of tuberculous ulcers (scrofulodermia). True Bazin's disease (erythema induratum) is generally regarded as tuberculous, and dermatologists describe other affections of the skin as being caused by infection with the tubercle bacillus, but these have no surgical interest.

LUPUS VULGARIS

This, the commonest form of primary tuberculous disease of the skin, begins as a subepidermal nodule, which is reddish-brown and somewhat translucent, and has been compared to "apple-jelly." As it increases in size the surface of the skin is raised, and other nodules appear in the vicinity There is a surrounding zone of hyperæmia and small-celled infiltration. The epidermis becomes thickened and scaly, and by the coalescence of the nodules a lupus patch is produced. Parts of the patch, generally those towards the centre, undergo retrogressive changes and may be converted into scar tissue, while the disease continues to spread at the periphery. The conversion into scar tissue is rarely complete, so that it is generally possible to detect one or more lupus nodules in the scar, which is usually thin and vascular. Beyond the periphery of the patch other nodules are present, and these may coalesce with the original patch and thus form an area of irregular shape. Ulceration, from destruction of the epidermis and septic infection, is very frequent; hence scabs and pustules are generally present. The disease lasts for years, often without affecting the general health; its progress may show temporary exacerbations. At first confined to the skin and subcutaneous tissues, it not infrequently extends deeply, involving and destroying cartilage and bone. Thus on the face the alæ nasi and septum nasi may be destroyed. The gums and palate may be likewise affected by direct extension.

Tuberculous deposits in the lymphatic glands may be present, and the development of an epithelioma in longstanding patches in old people is not unknown.

Etiology and pathology.—Lupus vulgaris is most frequent in children and young adults, and rarely begins after the age of 25. The face is the commonest site. The disease is not very uncommon on the extremities and trunk, but is rare on the scalp.

Microscopically the most striking feature of a lupus nodule is the

destruction of the normal elements of the affected part and their replacement by a mass of small-celled infiltration containing giant cells Typical tuberculous giant-cell systems may be present. Tubercle bacilli are scanty in number and are not easily found.

Diagnosis.—Syphilitic affections of the skin, lupus erythematosus, eczema, and rodent ulcer are the diseases most easily mistaken for lupus vulgaris.

From *syphilis*, lupus is distinguished by the presence of nodules in the skin outside the lesion. These nodules are soft, and on pressure with a glass slide to express the blood show the apple-jelly-like appearance. The scars of lupus are very liable to ulcerate and are thick, while those of syphilis are white, thin, and not so liable to break down. Sometimes the physical characters are quite inconclusive of the nature of the affection. The examination of the blood for the Wassermann reaction, the diagnostic tuberculin tests, microscopical examination of a section, and the effect of treatment by anti-syphilitic remedies, must be then employed.

The diagnosis from *lupus erythematosus* is sometimes difficult. This disease usually begins at a later age, after 30, and is symmetrical from the onset. It does not ulcerate or lead to destruction of the deep structures. It is most common on the scalp and ears—places where lupus vulgaris scarcely ever occurs. When lupus erythematosus begins on the nose it spreads symmetrically to the cheeks, giving rise to the so-called "bat's-wing" lupus.

Eczema is a superficial lesion without infiltration of the deeper parts. Moreover, there is no scarring in this disease.

Rodent ulcer usually is single, and should not be mistaken for lupus if attention be paid to the characters described at p. 673. A microscopic section of the edge of the lesion would make its nature clear.

Prognosis.—Patients do not die of lupus. But owing to the progressive destruction of tissues, very great deformities may be produced, especially when an area of any size is affected. The face may become hideous from destruction of the nose and contraction of scar tissue When the hands are affected the fingers may be crippled. The chronicity of the disease, with the difficulty in eradicating any nodule, and the liability to relapse even after apparent cure, must be remembered.

Treatment.—The essential point is the total eradication of the disease Therefore local treatment should always be persevered with until every part of the lupus tissue has been destroyed Fresh nodules should be vigorously attacked as they arise, and inasmuch as small patches are more easily dealt with than large areas, the former should be treated as soon as possible. General treatment may be employed in addition to the local measures.

There are many methods of local treatment—excision, scraping, exposure to the Finsen light and to the X-rays. Excision is the best whenever it is possible to employ it. Small patches can be removed and the edges of the wound sutured together. In the case of large areas, skin-grafting will be necessary to cover the raw area. The incision to remove the *affected area should be made not nearer than* ¼ in. all round the limits of the disease, and the whole thickness of the subcutaneous tissue should be removed. In this connexion it must be remembered that lupus of the ala nasi commonly begins *inside the nostril.*

Scraping alone is rarely sufficient. A paste of chloride of zinc, or pure carbolic acid, should be applied to the raw surface. A small sharp spoon is necessary to eradicate the small nodules and masses. A layer of sterilized protective, covered with an antiseptic dressing, may be applied to the raw area. Recurrence in the scar is not infrequent; the nodules must be again attacked by the small sharp spoon, or destroyed by a fine actual-cautery point, or by boring into them a match dipped in strong caustic potash solution or chloride of zinc paste The treatment must be thorough. The resulting scars are flat and smooth.

The Finsen-light method requires a special and costly installation. Only a small area can be treated at one sitting, which lasts from half an hour to an hour, and repeated sittings are necessary. The method may be used in combination with others. The best *effects are obtained by the use of a concentrated white light.* An excellent scar follows, but relapses appear to be frequent.

X-rays are most useful when ulceration is present. A pastille dose is given, and repeated in not less than four weeks. The results are variable: *it not infrequently happens that nodules remain* and cause relapse after the lupus has been healed for some time. Carcinomatous degeneration has been observed to follow in a number of cases, but it is only fair to add that this may occur after treatment by other methods.

Tuberculin has been much used in the treatment of this disease; it has not been very successful, and if used small doses should be given and the effects carefully observed.

Whatever treatment is employed, long continuance, often for years, is necessary. Even after apparent cure a relapse is very likely to occur.

TUBERCULOUS ULCERS (SCROFULODERMIA)

These ulcers may be primary in the skin or secondary. If the *former,* they are due to direct inoculation. If the latter, they are the result of a deeper-seated lesion, such as disease in the lymphatic

glands, extending to and destroying the skin. However produced, the ulcers are frequently multiple (Fig. 766). They have thin, undermined edges, surrounded by a ring of bluish, congested skin. The base is covered by pale granulations from which a watery discharge exudes and forms crusts and scabs on the surface. Imperfect healing followed by breaking down of the scar is common. Portions of skin may remain undestroyed, so that an irregular, puckered scar is often the final result.

Treatment.—Whenever possible, the ulcer should be excised wide of the disease and the edges of the wound sutured. When such treatment is not possible, a combination of scraping away all the softened portions and excision of the firmer parts may be employed and be followed by the application of chloride of zinc (40 gr to 1 oz). The raw surface is covered by a piece of perforated sterilized protective, and an antiseptic dressing applied. General tonic and fresh-air treatment will also be required, and benefit may be obtained by the use of tuberculin injections (*see* Vol. I, p. 129). Bier's congestion method, when the ulcer is in a situation convenient for its application, is beneficial.



Fig. 766.—Tuberculous ulceration of the skin.

The irregular scars are also shown. The depressed scar at the outer angle of the orbit was the result of tuberculous disease at the external angular process of the frontal bone.

When the ulceration is secondary to disease of glands, etc., treatment appropriate to those conditions must be adopted.

ERYTHEMA INDURATUM (BAZIN'S DISEASE)

This condition occurs most frequently in young girls. It affects commonly the posterior aspect of the lower third of the legs, and begins as deep-seated nodules in the subcutaneous tissue. As they

increase in size and approach the skin, this becomes bluish or r
in colour. Resolution of the nodule may occur, or ulceration
skin may take place, the ulcers being circular in outline and ind
The disease is often very chronic.

Diagnosis.—The only conditions which simulate this aff
are erythema nodosum and cutaneous gummata *Erythema no*
is an acute affection of the extensor surfaces: the individual n
are very painful, and tender on palpation. From *cutaneous gu*
the diagnosis is not always easy. The effect of antisyphilitic
ment, the result of Wassermann's test, and the presence of syp
lesions elsewhere, or a history of the disease, determine the diag
Positive reaction to a tuberculin diagnostic test would be in f
of Bazin's disease.

Pathology.—There seems to be no doubt that the affecti
a tuberculous manifestation. Bacilli have been found in the le
and inoculation experiments on guinea-pigs have given a po
result.

Treatment.—Rest in bed and elevation of the limbs sl
be prescribed, combined with general tonics. Tuberculin and
treatment may also be employed. A simple antiseptic dressing sl
be applied to the ulcers.

VARICOSE ULCERS

These ulcers are due to the faulty nutrition and retarded ve
return associated with varicosity, especially of the cutaneous ve
and smaller veins. The ulcer may arise in a patch of chronic de
titis or eczema, or may result from thinning and rupture of skin
a dilated vein A slight injury, which would produce no ill ef
in a healthy limb, may be the starting-point.

Pregnancy, by impeding venous return from the *lower limb*
an important predisposing factor Two clinical types of ulcer
seen. One is quite small, often deep, perhaps covered by a bl
clot, and placed over a dilated vein Such an ulcer is frequently
cause of the severe bleeding which may occur in varicose veins.
other type has the characters of an indolent or callous ulcer,
is due to neglect of cases of the first type. If the cases are of l
duration brown pigmentation of the surrounding skin is marked.

Both forms of ulcer are liable to severe complications. Pai
generally a prominent symptom, and is caused partly by expos
of the nerve terminals and partly by pressure of the inflammat
material in the adjacent tissues. Thrombosis of the veins lead
from the ulcer is often present; it is due to phlebitis, and is a comn
source of pain. Septic infection, both of the ulcer and of the s

rounding skin and subcutaneous tissues, always occurs. When the ulcer becomes chronic the surrounding skin becomes ill-nourished, hard, dense, and inelastic; in this condition it is shiny, smoother than normal, and adherent to the deeper parts ("hide-bound"). Lastly, if the ulcer involves a great part of the circumference of the leg, considerable œdema of the foot and interference with its movements may take place. Epithelioma occasionally supervenes on the ulcer.

Varicose ulcers are most common on the lower and inner part of the leg, but may occur on the outer aspect. It should, however, be remembered that not every sore on the leg of a patient with varicose veins is a varicose ulcer; many such ulcers are gummatous.

Treatment.—Prolonged rest and elevation of the limb to promote venous return and to relieve congestion are very important. At the same time the ulcer must be cleansed with soap and water twice daily, or by antiseptic fomentations frequently changed. If the ulcer is very foul the cleansing may be begun with a daily soaking in sanitas (1 : 10), or by the use of a chlorinated soda lotion (½ to 1 dr. to 1 oz.), eusol, or chloramine-T (1 or 2 per cent); if the surroundings are eczematous, these latter lotions should be confined to the actual sore. When the ulcer is clean, healing may be promoted by the use of an antiseptic ointment, such as ung. hydrarg nit. dil., spread on clean linen or lint. If the surface be sodden, great improvement can often be obtained by applying lint shaped to fit into the ulcer and lightly wrung out of a saturated solution of picric acid; here again it is advisable to protect the surroundings, if eczematous, with a mild ointment such as one containing dilute calamine.

If granulation and epithelialization of the clean ulcer are sluggish they can be stimulated by the use, on alternate days, of ung. borici and of a 4–8 per cent. ointment made of scarlet-red dye, or, better, of its active agent, amido-azo-toluol. It should be applied only to the ulcer, the surroundings being protected by calamine ointment. In using ointments the patient must be instructed to remove all old ointment before putting on fresh.

A weeping ulcer is often best treated with dry, powdery applications, such as calomel and zinc oxide in equal parts; a fairly clean but moist ulcer will often heal rapidly with frequent applications of a calamine and lime-water lotion.

Gypsum and charcoal have been recommended for the cleansing of ulcers with a foul exudate.

Aluminium acetate (1–2 per cent. lotion) dressings are often of value.

When the ulcer is very chronic and indurated, Unna's paste, strapping, and massage will be required.

Occasionally, when the tissues around the ulcer are firmly adherent to subjacent bone, or are deeply fibrosed, healing will not occur till they have been separated by a series of subcutaneous punctures made through healthy tissue. In these cases scarification or blistering of the surroundings, judiciously performed, may expedite recovery. A very large ulcer may require skin-grafting, followed by three months' rest in the supine position.

When the ulcer is clean, epithelialization is hastened by the use of a single layer of openwork "Leno" protective, which can be left *in situ* for several days, any exudate being washed away daily from its surface and a clean superficial dressing applied.

If the ulcer is large and has been thoroughly cleansed, epithelialization may be hastened by skin-grafting; a small ulcer may be excised *in toto* and the raw surface covered with grafts. The scar is often stronger and more flexible after skin-grafting than after other methods of treatment, provided that care is taken of the grafts, that they do not become dry, and that too early use of the limb is not allowed.

Finally, attention must be paid to the veins, the primary cause. They must be supported by elastic bandages (crêpe Velpeau or Martin's), or by elastic stockings made to give general support but not to constrict above. If the condition of the skin permits, the veins may be operated upon

Recently, Leriche and other French surgeons have practised periarterial sympathectomy, or the removal of the sympathetic coat of the main artery of supply, but the results have been inconclusive or disappointing

The necessity for change of treatment as the ulcer passes through different phases is as a rule insufficiently realized

GUMMATOUS ULCERS

Gummatous ulceration of the skin (*see also* Vol. I., pp. 791, 827) may occur anywhere, but is perhaps commonest in the lower limb, especially over the upper end of the tibia, around the patella, and in the lower part of the leg.

Pathology.—Frequent in both sexes and in both acquired and congenital syphilis, gummatous ulcers may occur at any age, even in childhood.

A gumma begins in the subcutaneous tissues as a rounded cellular nodule; it increases till it reaches the skin, which becomes reddened and thinned and finally gives way, leaving the gummatous material, now secondarily infected, exposed as a greyish-yellow mass ("wash-leather slough").

Clinical features.—The ulcer may be single, but more

frequently several lie close together; by destruction of the intervening skin these fuse to form a larger ulcer with a serpiginous edge. The ulcers may be grouped, or scattered singly over a considerable area. In the lower limbs bilaterally symmetrical distribution is common.

The ulcer generally presents a well-defined steep edge, a rounded or oval shape, and a base smooth and covered with granulations, or with the "wash-leather" slough if this has not yet separated. The surrounding skin may look healthy, or may show signs due to acute or chronic secondary infection with pyogenetic organisms. In these circumstances the original characters of the ulcer may be lost or much obscured. If the ulcer is large or deep, considerable destruction of the skin and other tissues may occur.

When healing takes place a characteristic scar is produced. It is thin and supple, dead white in colour, and not adherent to the subjacent tissues. It is often also slightly depressed and usually oval or circular in shape. Moreover, unlike a lupus scar, it has very little tendency to break down.

A chronic syphilitic ulcer, like any other sore of prolonged duration, often leaves a scar surrounded by a zone of dark pigmentation.

Diagnosis.—The clinical features enumerated will generally betray the cause of the ulceration, especially if characteristic scars elsewhere, or other signs of syphilis, can be found.

Syphilitic ulcers may appear on legs with varicose veins, but are not therefore to be called varicose ulcers. A past history of syphilis may be unobtainable, and the Wassermann reaction is not always definitely positive.

Treatment.—General treatment by the administration of iodides, mercury, and salvarsan or neo-salvarsan must be combined with local attention. Gauze soaked in perchloride of mercury (1 : 2,000) may be used, or mercurial ointments, frequently applied on linen or lint, after removal of all old ointment. If healing is slow, a 4–8 per cent. scarlet-red ointment or a 2-per-cent. solution of aluminium acetate may be tried. Unless the general health of the patient is maintained, healing will not occur: rest in bed, when the lower limbs are the seat of the ulcers, warmth, and good food are essential; cod-liver oil and malt is a very valuable adjunct, particularly in the congenital cases.

When pyogenetic infection is marked, removal of all dead epithelium and vigorous cleansing must be instituted; unless this is done, the full benefit of the general treatment will not be obtained. Where there is much thickening of the skin, the treatment described under Varicose Ulcers may be employed.

TUMOURS OF THE SKIN

Tumours of the skin may be classified according to their origin, as (1) epithelial growths arising in the epidermis and the structures belonging to it, (2) connective-tissue tumours arising in the corium.

Innocent epithelial tumours are solid (warts, corns, molluscum contagiosum, and moles) or cystic (sebaceous and implantation cysts).

Malignant epithelial tumours are squamous-celled carcinoma, rodent ulcer, melanoma (melanotic carcinoma), and Paget's disease (dermatitis maligna).

Innocent connective-tissue tumours include the hard and soft fibromas, molluscum fibrosum, and nævi. Cheloid is sometimes regarded as a tumour, but it is dealt with in this article under Affections of Scars.

Malignant connective-tissue tumours are sarcomas, which may be single or multiple.

Secondary malignant tumours—sarcoma and carcinoma—are not infrequent in the skin. Both endothelioma and perithelioma occur. These tumours have characteristic microscopic appearances (*see* Vol. I., p. 450), by which alone they can be diagnosed with certainty.

INNOCENT TUMOURS

Warts (Verrucæ) [1]

These growths are due to hypertrophy of the papillæ of the skin, and are covered by an overgrowth of the epidermis. They appear in many different forms—(1) the flat wart, (2) the pedunculated wart, (3) the senile wart, (4) verruca necrogenica.

Flat warts *are found specially on the hands, forearms, and face,* in children and young adults. They are frequently multiple, and begin as a roughening of the epidermis. The adjacent skin is healthy. The size steadily increases, *the surface becoming irregular and of a grey, brown, or* black colour (usually due to dirt particles). A slight degree of constriction, forming a sort of pedicle, may be present at their attachment. Several warts may appear close together and coalesce *into a large irregular mass.* They come and go suddenly in crops, and may persist for a long time. They only cause trouble by their unsightliness and by a tendency to hæmorrhage when injured. Though the infecting agent is not known, *warts are almost* certainly infectious.

Treatment.—The local application to the individual wart of 10 per cent. salicylic acid collodion or of glacial acetic acid or fuming nitric acid once a week by means of a glass rod is often sufficient. X-rays are often very beneficial; several applications may be necessary. The dosage and frequency of sittings require careful adjustment; this treatment should therefore only be undertaken by one skilled in X-ray therapy.

Zinc ions are often efficacious. The wart is transfixed by a zinc needle, and a current of 1 ma. for one minute is sufficient for small warts. Magnesium ions are also useful. Solid CO_2, in the form of a stick or pencil cut to the size of the wart, may be applied for about thirty seconds. The applica-

[1] *See also* Vol. I., p. 477.

tion is painless, but considerable pain may follow, as a blister develops in a few hours. A simple ointment should be applied and the part kept bandaged. *Thyroid extract and sulphate of magnesium given internally appear* to be beneficial in some cases.

Pedunculated warts (filiform warts) differ from the preceding in that there is an excessive overgrowth of the papillæ and a much more exuberant mass is produced, many of the individual portions being pedunculated. They are commonest on the genital organs (Fig. 767) of both sexes, and often follow an attack of gonorrhœa. Apart from this disease they may be due to the irritation of retained secretion and inflammation of a long prepuce. When numerous they often cause an offensive discharge. Warty growths are also seen in connexion with condylomata on the vulva and anus.

Treatment.—In mild cases, strict cleanliness and the application of a dusting powder (salicylic acid 1 dr., boric acid 1 dr.) may be sufficient. If gonorrhœa is present it must be treated. In more severe cases the warts may be snipped off and their bases cauterized. When large masses have to be excised, a general anæsthetic must be given, and, unless the incisions are made just beyond the limits of the mass, severe hæmorrhage may occur. If the prepuce is long, circumcision should be performed.



Fig. 767.—*Warts on penis.*

Satisfactory results may be obtained also by the use of X-rays, but repeated applications will be necessary, and they should only be carried out by a skilled radiographer.

Senile warts (verruca senilis vel seborrhoica) usually occur in later life, but sometimes young adults are affected; they appear as brown or black flat warts on the face, trunk, or limbs. They may be multiple, soft, and greasy to the touch; sometimes they are the starting-point of malignant disease. The overgrowth of the papillæ may be comparatively small while the amount of pigmentation is great, so that a pigmented patch is produced. The skin may be abnormally greasy.

Treatment.—If they are unsightly or are increasing in size, they should be removed either by excision or by a course of X-rays.

Verruca necrogenica (anatomical tubercle or lupus) occurs on [illegible]

what tender, and may be covered by a scab from drying-up of serum exuded from cracks or fissures. The disease is very indolent and chronic, and not easy to cure. Tubercle bacilli have been demonstrated in the bases of the

warty growth, and occasionally the lesion has been the starting-point of tuberculous disease in the epitrochlear or axillary glands or elsewhere.

Treatment.—In some cases protection of the affected part and the application of salicylic-acid (25 per cent.) plaster is all that is required. Excision, with subsequent skin-grafting if necessary, or the repeated application of X-rays, will be required when no benefit accrues from milder measures.

CORNS[1]

corn. The central ingrowth, which is a simple thickening such as is often seen on the hands of workmen and others as a result of frequent intermittent pressure or friction.

Etiology.—True corns are usually found on the feet, the outer side of the little toe and the head of the metatarsal bone of the big toe being the most frequent sites. Less often they occur on the heel or in the middle of the sole; in these situations the thickening is perhaps more often a callosity, which may involve a large area of the skin. A not infrequent position for a corn is over the heads of the phalanges, especially when there is any tendency to hammer-toe. The usual cause is the wearing of tight or ill-fitting boots

Pathology and morbid anatomy.—Two varieties are described: (1) The *hard corn* forms a more or less circular swelling, projecting above the level of the surrounding skin, the edges shelving down to adjacent skin; the colour is yellow, with a somewhat darker centre. (2) The *soft corn* occurs between the toes, where, owing to the warmth and the presence of sweat, a sodden, whitish appearance is presented.

Beneath the corn a space containing fluid—a false bursa—is liable to form owing to the tissue atrophy produced by the pressure of the epithelial mass. Irritation and microbial infection cause inflammation or even suppuration, with subjacent abscess-formation. This, if neglected, will produce a surrounding cellulitis, or a septic arthritis in a neighbouring joint.

As a result of the inflammation the corn may "slough off" and leave a chronic ulcer. In patients affected with tabes dorsalis and some other nervous affections a hard corn under the ball of a toe is frequently present. Inflammation and subjacent suppuration often attack such a corn and lead *to destruction of the tissues and a "perforating ulcer of the foot."* In these patients the amount of pain is usually slight. In old people, when the arteries are atheromatous, inflammation following "paring the corn" may be the starting-point of senile gangrene.

...mptom is pain. It is due to the ... on the nerve terminals and to ...xaggerated by any condition, ...he congestion.

...palliative.—The foot must be kept *scrupulously clean and dry, especially in the case of soft corns.* Pressure must be avoided on the prominent parts of the foot and over the corn; in many patients it is necessary to have the boots specially made.

[1] *See also* Vol. I., p. 478.

If the corn is between the toes a small piece of boric lint or a gauze pad may be inserted to relieve the pressure; sometimes a piece of rubber strapping may be so fixed around the toe and foot as to separate the toes. A powder of salicylic acid (2 dr.) and boric acid (1 oz.), dusted between the toes, is often useful to keep the parts dry. A ring of felt plaster, applied so that the corn is in the centre of the ring, serves to relieve the pressure when the corn is on the sole or on one of the toes.

2. **Radical.**—After thoroughly soaking the corn in hot water, the dense part may be removed by means of a razor or sharp scalpel, which should cut parallel to the skin, great care being taken not to cut deep enough to draw blood or to injure the underlying tissues After several shavings it may be possible to remove the central core; and in the absence of further pressure the skin will become normal. Salicylic collodion (salicylic acid 60 gr., extract of cannabis indica 6 gr., collodion 1 oz.) may be painted on daily for a week. At the end of this time the thickened epidermis may be removed. If the corn is large, it may be excised and the wound sewn up. Another [illegible]

per cent.) may be used with advantage both before and after the treatment (Lewis Jones)

When the corn is suppurating, pain is often intense, though there may be only a drop of pus confined in the bursa beneath it. In such a case, under nitrous-oxide gas anæsthesia, the corn should be transfixed by a sharp knife and the pus evacuated, or it may be excised and hot fomentations applied; these are changed for an antiseptic dressing when the inflammation has subsided.

Fibromas of the skin are described elsewhere (Vol. I., p. 397).

Painful Subcutaneous Nodule [1]

This is a small fibrous tumour developing in connexion with a cutaneous nerve filament. It is intensely tender, even on the lightest touch; the tenderness may increase with the duration of the disease, and sometimes gives rise to severe neuralgic pain radiating along the limb. The condition is more frequent in women. Treatment consists in removing the tumour and in attacking the neurosis so frequently associated with it.

Molluscum fibrosum and *von Recklinghausen's disease* are considered in Vol. I, pp. 397, 400.

Moles

These are pigmented swellings or patches occurring in the skin. The former may be single or multiple. They appear as raised tumours, usually of a dark-brown or black colour. They are generally regarded as epithelial in origin, and may be the starting-point of malignant disease (melanoma). A mole which is undergoing malignant changes usually begins to ulcerate and to bleed freely. But without these local changes dissemination may occur.

[1] *See also* Vol. I, p. 400.

When a mole occurs as a pigmented patch, it may involve a large area of skin, or there may be many such small areas scattered over the body. The degree of pigmentation varies. In both forms hairs, abundant or scanty, short or long, may be present.

Treatment.—Multiple small moles should be left alone unless they are on an exposed part and cause disfigurement. Hairs may be removed by inserting into each follicle in turn a needle attached to the negative pole of a galvanic battery and passing a current of 5 ma. till the hair is loose; this treatment will cause much of the pigmentation to disappear. The application of solid CO_2 also efficiently removes a small hairy mole. A mole which is increasing in size or is beginning to ulcerate should be freely excised.

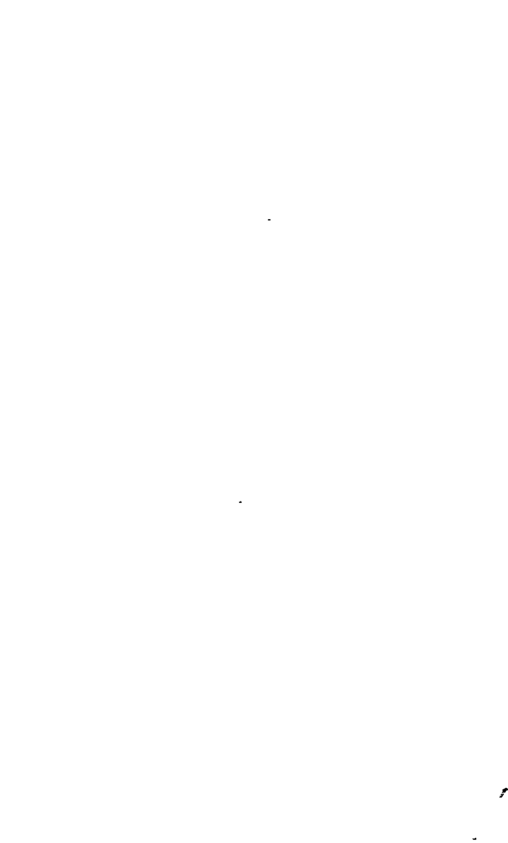


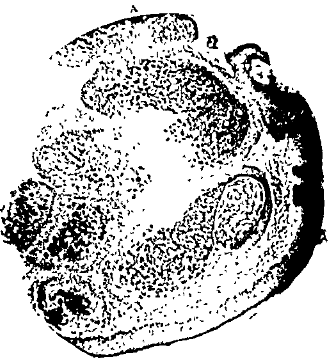
Fig. 768 —Hairy mole on face, treated by excision and immediate skin-grafting.
(Photograph kindly lent by Mr James Berry)

Large hairy moles should be removed completely whenever possible. (Fig. 768.) If a raw area is left which cannot be closed by sutures, it should be covered with Thiersch skin-grafts at once. In some instances Sir Victor Horsley's method may be useful. This consists of turning down a flap containing the mole, and removing from the deep aspect of the flap the parts containing the hair-follicles. The flap is then replaced. The pigmentation remains, but no further growth of hair should occur.

Molluscum Contagiosum

This affection is characterized by the presence of a number of small, firm, rounded, bluish bodies, with a definite depression in the centre. They are solid, and on firm compression a whitish mass may be extruded from the interior through the central opening. Commonest on the face end neck of children, they may also appear elsewhere; they occur less frequently in adults The size of an individual tumour is not often greater than that of a split pea. Cure may follow spontaneous shedding or suppuration They are undoubtedly infective, though the exact nature of the infective body is not known. Microscopical examination of the tumours shows that they do not




A


B

originate in the sebaceous glands. They consist of a mass of epithelial cells; towards the centre the cells undergo a peculiar hyaline degeneration, giving rise to the so-called "molluscum bodies" (Plate 128); at one time these were supposed to be psorosperms

The **treatment** consists either in incising and squeezing out the whole contents of the tumours and then touching the interior with pure carbolic acid, or in snipping them off at their bases with scissors.

Sebaceous Cysts

These cysts (Fig. 769) form the commonest skin tumours. Their general characters and complications have been already described (Vol. I., p. 625) Epithelioma may arise in an unruptured or subcutaneously ruptured sebaceous cyst, as also in the foul discharging cavity or surface that may persist indefinitely after suppuration and incision or rupture.



Fig. 769.—Sebaceous cysts of scalp.
The skin over the larger cyst has ulcerated

Diagnosis.—A *dermoid cyst* is distinguished by the fact that it occurs only in certain situations and is not attached directly to the skin. It is also usually congenital in origin, and is single. From a *lipoma* a sebaceous cyst differs in its rounded or globular outline, its tense feeling, and its fixation to the skin at one point; a lipoma, on the other hand, is lobulated, is softer, and is attached to the skin at several points. Moreover, the edge of a lipoma is frequently irregular, and not so smooth and rounded as is that of a sebaceous cyst. A *gumma*, especially one in the scalp, may be mistaken for a sebaceous cyst. It is distinguishable by its deep attachments and its greater fixity, it is usually situated in the fronto-parietal region; it has not the rounded outline of a sebaceous cyst, and is often firm at the periphery, while the centre is softer. Evidences of syphilis may be present elsewhere, and a course of iodide of potassium and mercury will cause the tumour, if a gumma, to disappear.

Treatment.—Sebaceous cysts should be removed if increasing

in size, if inflamed or suppurating, or if causing disfigurement. They are readily removed by enucleation or by dissection; in the scalp the former method is employed, in other situations the latter method may be necessary. On the scalp the hair must be shaved for at least half an inch all round the tumour, and the skin thoroughly disinfected. The tumour may be transfixed by a narrow-bladed knife, which is then carried upwards, dividing everything to the surface. The contents of the cyst are squeezed out, and the divided wall seized on each side and twisted out, any firm bands of connective tissue being severed by the knife. The cyst may also be excised entire. When it is large and the skin is much stretched, an elliptical portion of the skin should be removed with the cyst. When the cyst is inflamed, removal of the entire wall is preferable to opening, scraping, and draining, for after such incomplete procedures a recurrence of the cyst is not unlikely.

Implantation Cysts

These arise from the accidental transference of portions of the skin and epithelium into the subcutaneous tissues. They are most frequent on the hand as the result of a penetrating wound, but are also found in the cornea and iris after an injury. They have been called *traumatic* and *acquired dermoids*. The signs and treatment are similar to those of a dermoid cyst.

Mucous cysts on the inner aspect of the lips (*see* Vol. I, p. 626) should be dissected out and the wound closed by sutures.

Horns[1]

Horns usually arise in connexion with a sebaceous gland, and are most common in the situations where sebaceous cysts are found, i e. on the head and face. Generally they are single, and met with in adult life A conical structure is produced by the progressive deposit and desiccation of exuding sebaceous contents Its size depends on its age and the rapidity of the exudation. The base is formed by a sebaceous cyst or gland, and is often inflamed. The density of the horn varies, whilst its colour is often dark from the presence of dirt. Treatment consists in removal of the horn together with the skin at its base or the sebaceous cyst from which it originates.

Angioma—Nævus

The characters of nævi have already been sufficiently considered (*see* Vol. I, p. 438), and only their **treatment** remains to be discussed. Excision, electrolysis, the actual cautery, the application of solid CO_2 and radium are the best methods. The most important point is to ensure destruction of the whole of the nævoid tissue, otherwise

[1] *See also* Vol. I., pp. 479 and 626.

recurrence will take place. The method chosen should be the one which will leave the least amount of scar tissue. A nævus, whatever its size, should be treated as soon as possible after birth; even quite small nævi should be dealt with.

Excision is the method of choice, and should be used whenever practicable, being the most rapid and most certain method of cure. The incisions should be made just outside the nævus tissue: hæmorrhage is thus avoided, and only one or two vessels will require ligaturing. A little undermining of the subcutaneous tissues may be necessary to bring together the edges of the wound in the case of very large nævi.

Electrolysis is a more tedious method of cure. It is suitable when the nævus is entirely or partly in the subcutaneous tissues. The object of the method is to cause coagulation of the blood, and a sufficient reaction to lead to the slow disintegration of the nævoid tissue For small nævi one application may be enough; large nævi will require several. The interval between the applications depends on the effect produced. The patient should be anæsthetized. Needles connected with the positive and negative poles may be introduced into the nævus when it is of large size.

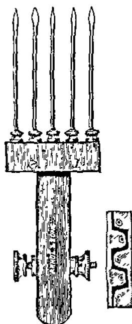


Fig. 770—Needle-holder for use in electrolysis of a nævus.

(*Lewis Jones*)

The needles should be of platinum, as steel needles are liable to cause black spots. When the needles are in position in the nævus, those connected with the positive pole must not touch those connected with the negative pole To avoid this a convenient needle-holder is shown (Fig. 770). The number of needles required will depend on the size of the nævus; a current of 15–20 ma. will probably be sufficient. The effect of the current is carefully observed and its strength regulated accordingly, beginning at zero. From five to ten minutes is a suitable time for the duration of the electrolysis. At the positive pole clotting takes place, and a firm, hard nodule is produced; at the negative pole destruction and gas production ensue. After a positive needle is withdrawn some bleeding may occur. The position of the needles must be changed from time to time as the nævus becomes hard and firm; it is important to avoid sloughing, and therefore the current must not be allowed to act too long at any

one place. The peripheral portion should be first treated, essential to destroy this part because growth occurs her the operation an antiseptic dressing, such as iodoform ʒi *Iodion* ℥i, *should be applied* It should not be left on than four days. Any bleeding that may occur on withdraw *positive needles is easily* arrested by pressure.

The galvano-cautery is a very useful therapeutic ins Variously shaped cautery *points, according to the size of th* are required. The point at a dull-red heat is plunged into portions, and special care is to be taken to destroy the edge imperative to destroy the whole thickness of the nævus, par when it is on the scalp and on the forehead, where it may exte to the bone A simple antiseptic dressing is applied at the en operation.

Treatment with *solid* CO_2 is good for thin nævi; it i be used when the nævus is of any thickness. A blister is p (which may require puncture), a small scab follows, and separates a soft scar remains. A single application of abou seconds may be sufficient, it is better to repeat the treatmen than attempt too much by one application. The interval the applications depends on the amount of reaction

Radium affords an effective means of treatment; the appl are followed by dwindling, with comparatively little reacti *therefore little or no scarring.*

Very large capillary nævi are best left alone, though so some improvement may be obtained by tattooing with the g cautery, or by the application of solid CO_2, or of radium. time will be required to produce a satisfactory improvement

Rhinophyma

This affection of the skin attacks the lower end of the nose condition is also known as *hammer-nose* and *lipoma nasi*, th *term being a misnomer*, for there is no fat in the tumour-lik which is the result of an overgrowth of the sebaceous glands panied by a dilatation of the blood-vessels A prominent lo growth is produced (Fig. 771), and the skin over it is thicken and greasy. The capillaries are enlarged and form tortuous The orifices of sebaceous glands are *visible, and may be* with secretion. A very unsightly deformity is produced. Th *tion usually* occurs in men in middle or advanced age.

Treatment consists in free removal of the mass until tissues are exposed, carrying the paring, if necessary, as d the nasal cartilages, but taking care to avoid opening the cavity. A large area of skin may have to be excised.

grafting will generally be necessary, and should be done at the time of removal.

MALIGNANT TUMOURS

Rodent Ulcer

This form of malignant disease is usually met with in elderly patients; occasionally it occurs in those under 40 years of age. Its pathology has been already discussed (Vol. I., p. 561).

Clinical features.—A rodent ulcer may occur on any part of the skin; the side of the nose just below the orbit, the forehead, and the parotid region are the most common sites. It begins in an insidious manner as a pimple or a papule, which may undergo no change for months or years. Then the papule may begin to bleed after a trifling injury, or a small scab may form on it as a result of slight ulceration; an increase in size follows, and as this proceeds ulceration progresses at about the same rate, so that very little growth may be present. From time to time healing may occur, but the scar is not sound, and is destroyed by the growth continuing to extend beneath it. The ulcer has a reddish base or surface, which may be smooth or slightly nodular. The edges, often sharply cut (Fig. 772), may be raised above the level of the surrounding skin, beneath which it is often possible to feel the infiltrating growth that may give rise to a slight amount of induration. In the absence of any sepsis, the amount of discharge will be quite small. The lymphatic glands are not affected, and dissemination does not occur. The progress of the disease is so slow that it may be spread over many years; but it



Fig. 771.—Rhinophyma.

The lobulated appearance of the tumour and the dilated orifices of the sebaceous glands are shown.

will successively destroy all the tissues, even bone; thus a great part of the face, including the eye and the skull-bones, may be eaten away. The affection is painless, unless nerves are affected, and the general health does not suffer.

Treatment.—Of late years the treatment of this affection has been considerably changed. Excision alone is not now frequently employed; it has been replaced by the X-rays and radium, and zinc ions. Excision is used in combination with these methods when the ulcer is very large, or when the bones or cartilages are diseased. In such circumstances the greater part of the ulcer is removed by the knife, the remainder being treated by X-rays. It is always necessary to remove any infiltrated bone or cartilage; experience shows that treatment by X-rays or by radium in these cases is not likely to be of any value.



Fig. 772.—Rodent ulcer of the forehead.
The ulcer was cured by X rays in pastille doses

In excising a rodent ulcer, at least half an inch of tissue all round and beneath the growth must be removed. The defect is closed by suturing the edges, skin-grafting, a plastic operation, or a combination of these methods.

X-ray treatment is particularly suitable for ulcers on the face; the scar is almost invisible, and is soft and supple; deformity from contraction is thereby avoided. The technique of the application of the rays varies somewhat. In one method the tube is placed a short distance from the ulcer, which is exposed to the rays for five to ten minutes three or four times weekly until sixteen to eighteen sittings have been held. Treatment is then stopped for two or three weeks, by which time the amount of reaction that has been produced may be estimated. A second course is now begun, and is continued until a flat granulating surface is obtained, which indicates that all the growth has been removed. A simple antiseptic ointment is now

applied until healing is complete. Another method of using the X-rays is to give a maximal dose at intervals, this dose being measured by a pastille which changes colour to a standard tint when the amount of X-rays applied is the largest that can be used without giving rise to erythema. The dose is repeated in three weeks.

Radium is now frequently employed in the treatment of rodent ulcer; it is applied in special tubes or applicators placed directly on the ulcer, and the whole area of the ulcer is treated in succession. The length of the exposure varies with the amount of radium employed, the thickness of the tube, and the size of the ulcer. More than one application may be required. The patient must be seen from time to time, and the radium reapplied as may be necessary.

Good results are obtained by both methods. The scar is thin, pliable, and almost unnoticeable. Recurrences may take place, and should be treated in a similar manner.

The method of treatment by zinc ionization is described elsewhere (Vol. II, p. 715).

Carcinoma of the lips is considered in Vol. I., p. 564.

Epithelioma of the Skin[1]

Squamous-celled carcinoma is most frequently met with on the hands or the face (Fig. 773). It occurs in two forms: (1) As a flat, warty growth which is usually of slow development and is not very malignant; the lymphatic glands are not affected at all, or only late in the course of the disease. (2) As an indurated, ulcerating, nodular growth which extends rapidly and infiltrates the surrounding tissues. The lymphatic glands are affected early.

Treatment.—Excision must be employed whenever possible. In the first form the operation is very satisfactory as a rule, and unless the glands are enlarged they need not be removed. The patient should be seen at short intervals in order that the glands may be removed at the earliest possible moment, if they enlarge. In this form treatment by radium may sometimes be employed instead of excision. The length of exposure depends, of course, on the quantity of radium employed and the size of the growth. More than one application may be necessary.

In the second form, only free excision is likely to be of benefit. In some cases—e.g. when the hand is affected—amputation of the whole or part of it will be required. An important question is the removal of glands. If obviously enlarged they must be removed together with surrounding cellular tissue. It does not seem to be necessary to excise the lymphatic vessels intervening between the growth and glands. If the glands are not enlarged it is best to remove

[1] *See also* Vol. I., p. 554.

that group into which the lymphatics of the part drain, at the same time as the removal of the tumour is undertaken.

Chimney-sweep's cancer is considered in other volumes (*Vol.* I., p. 593, and Vol. II., p. 1027).

SECONDARY CARCINOMA AND SARCOMA

The skin and subcutaneous tissues are not infrequently affected



Fig. 773.—Epithelioma of the cheek.

The glands in the submaxillary region were considerably enlarged. They were excised, and the tumour treated by radium. *It almost completely disappeared, but the patient died in a few months.* There were secondary masses in the left pectoralis major, and in the abdominal muscles of the left side. No recurrence took place in the glands.

by secondary carcinoma and sarcoma. The breast is the most common situation of the primary carcinoma, and the eyeball or a mole on the skin is the seat of the primary sarcoma (or, as it is now generally called, "melanoma"). In both varieties there are numerous nodules distributed all over the body (Fig. 774). At first the skin over the nodule is normal, then it becomes adherent and reddened, and finally it may become ulcerated, but this is not very common. When the nodules are secondary to a melanoma or pig-





Extensive melanotic sarcoma of the chest in a chimney-sweep aged 32

The tumour began in a mole, and had been growing for two years.

PLATE 129.

mented sarcoma the pigment may give to them a dusky or black appearance. The quantity of pigment in the separate nodules varies: some may have a large amount and be quite black; others have none, or a very small amount. Further, the quantity of pigment in the primary and secondary nodules is not equal. These secondary growths are generally painless, and give rise to no symptoms, at least in the early stages.

Paget's Disease (Malignant Dermatitis)

This condition occurs most often in the skin of the breast around the nipple, but is sometimes seen in other regions—the abdominal wall and on the external genitals. It is fully described elsewhere (Vol. I., p. 597, and Vol. II., p. 11).

Melanoma

Melanomas are primary tumours of the skin containing a black pigment—melanin. (Plate 129.) Pathologically they have been described both as sarcomas and as carcinomas (*see* Vol I., p. 517). The amount of pigment may be slight, or so great as to colour the whole mass a deep black. The primary growth may contain little pigment, whilst *the secondary growths are deeply* pigmented. The average duration of life is about two to three years, though instances are known in which the patient has survived for much longer periods.

Treatment.—Free excision or amputation, according to the situation of the primary growth, is the proper course to adopt when secondary dissemination is absent. A wide area of skin, of the subcutaneous tissue around the growth,

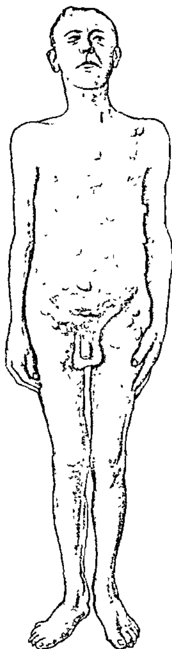


Fig. 774.—Multiple secondary deposits in the skin and subcutaneous tissues in a case of sarcoma (?) of the right eye in a man of 59.
(Drawn from a photograph.)

and of the structures beneath it to the deep fascia, should be removed. The removal of the lymphatic glands should be carried out in all cases, even though they are not obviously *enlarged*; *section of* them frequently shows the presence of melanotic deposits in these circumstances.

AFFECTIONS OF SCARS

EXCESSIVE CONTRACTION

This may cause great deformity or serious interference with the movements of any joint, as exemplified by Fig. 775. After an amputation of the breast the axillary portion of the scar not infrequently contracts to such a degree as seriously to limit the movements of the arm if care be not taken to keep the arm fully abducted during the healing stages, and if *early movements are not practised.* Excessive contraction is especially likely to occur after severe burns, or when the skin and subcutaneous tissues have been extensively destroyed by other injuries.

Treatment.—During the healing of the wound the parts must be kept *in such a position as will oppose the contraction.* When the area to be healed is large, a supple scar must be produced by skin-grafting or other plastic operation. If excessive contraction is already present, the scar must be excised or divided and freed from the deeper parts, any contracted bands being also divided; due regard must be paid to the proximity of important vessels and nerves. The raw areas left are covered by Thiersch's skin-grafts or by a plastic operation. Several operations may be required to obtain a satisfactory result. (Fig. 776.)

OVERGROWTH, OR HYPERTROPHY

When a wound heals by first intention the resulting scar usually consists of fibrous tissue covered by epithelium. In the course of time the blood-vessels become so small that the scar is finally almost bloodless, and has a white or pinkish-white colour. But sometimes the vascularity persists, and the colour remains a deep red; at the same time the amount of fibrous tissue is increased in quantity and *the scar is raised* above the level of the surrounding tissues, and also has a firm or hard consistence. When a scar undergoes such a change it is said to be *hypertrophied*, or to show an overgrowth of scar tissue. The causation of this change is quite unknown. *It is* perhaps more common when the wound has not healed by first *intention and* when *sepsis* has been present, though this may have been quite slight. Thus, overgrowth is not infrequently seen in the scar of the wound where the drainage-tube has been placed in the axilla

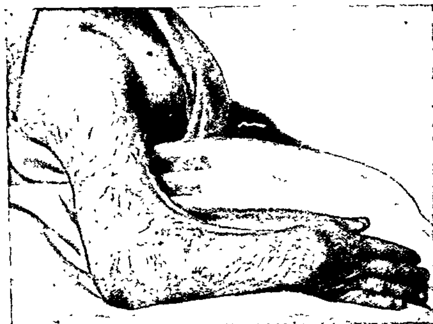


Fig. 775.—Deformity of upper limb caused by contraction after a severe burn.

after amputation of the breast, whilst the scar formed by bringing together the edges of the incision for the removal of the breast itself is quite healthy. It would appear that this overgrowth is

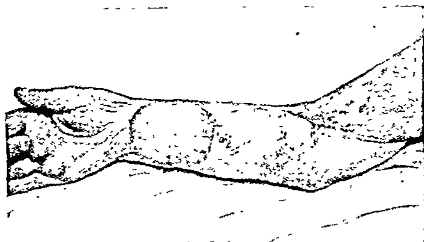


Fig. 776.—Same arm as in Fig. 775, after performance of several plastic operations.

The oval area just above the wrist is a large flap taken from the abdominal wall.

more likely to affect scars in the subjects of tuberculosis, and also scars that follow burns.

Cheloid

This is a condition of great overgrowth in a scar. (Fig. 777.) Formerly two varieties were distinguished—the *false*, and the *true or Alibert's cheloid.* The latter was supposed to arise spontaneously, but it is now generally considered to be always secondary to a scar, though this may be quite small, such as that following an acne pustule or even a needle-prick.

The **etiology** is not known. Though frequently seen in tuberculous subjects, cheloid also occurs in people free from tuberculosis. In some patients the smallest scars will become cheloidal. The presence of sepsis also appears to predispose to this condition.



Fig. 777.—Cheloid scar following operation for acute appendicitis. The abscess cavity was drained.

Morbid anatomy.—In cheloid the scar becomes much thickened, dense, and raised above the surface of the skin. Its colour is pink or red. The margins of the scar are often irregular and send out into neighbouring tissues claw-like bands or processes. The shape of the cheloid depends on that of the original scar; where this is irregular or broad, great deformity may be produced by the contraction of the cheloid. Microscopically, a cheloid consists of fibrous tissue with a large number of spindle cells (Fig. 778); in the centre and older parts of the tumour there are comparatively few vessels. In structure, therefore, it is allied to fibroma or spindle-celled sarcoma. The condition extends more deeply than is generally recognized, and can be traced along the vessels down to the subjacent muscle fascial layer. This fact is of importance when treatment by excision is under consideration.

Symptoms.—Cheloid is often attended with pain, tenderness, and some irritation or itching. On an exposed part it may cause great disfigurement. After persisting for a time a cheloid may spontaneously disappear or may ulcerate.

Treatment.—This is not very satisfactory. X-ray or radium treatment should be first used and may be successful. Excision has

often been done, but recurrence is liable to take place not only in the scar but in the stitch-marks. If excision is considered advisable, it is essential to remove all the claw-like processes or prolongations, and also to remove the tissues right down to the underlying fascial plane, otherwise the condition will certainly recur. In the case of an irregular scar it may not be possible to bring the edges together after such a removal has been effected; therefore any raw surface left should be skin-grafted.

If a scar tends to become hypertrophied or to develop into cheloid

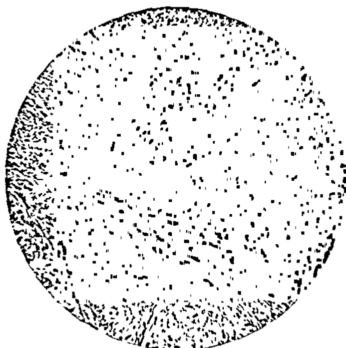


Fig. 778.—Section of cheloid showing the bundles of spindle cells.

it may be painted in the early stages with collodion, with the idea of diminishing the vascular supply.

WEAK AND ULCERATED SCARS

By a weak scar is meant one which is very thin and adherent to the underlying tissues; frequently it becomes the seat of a *permanent* ulcer or of recurrent ulceration. The scar is generally a large one, such as follows a burn or a chronic ulcer of the leg. It is often situated over a bone—e g the tibia—or at the end of an amputation stump when the scar has become adherent to the divided end of the bone. Nutrition is defective, and any slight injury is liable

to be followed by a spreading ulceration which is very intractable to treatment.

Treatment.—A large wound should be skin-grafted to obtain as strong a scar as possible To remedy a weak scar a plastic operation, with skin-grafting, will be required. The flap may be taken from the adjacent skin and transferred to the raw area. It is essential to free the surrounding skin and subcutaneous tissues from the underlying structures so as to allow sufficient contraction to take place. If the scar is adherent to an underlying bone—e.g. in an amputation stump—it is often necessary to remove a portion of the bone, enough being taken away to allow the refreshed edges of the scar to be brought into apposition without tension.

PAINFUL SCARS

These are caused either by the implication of the terminals of nerves in the cicatrix, or by the formation of a "bulbous end" on a nerve. As the fibrous tissue contracts its pressure causes severe pain and a certain amount of neuritis. A feature of these painful scars is the liability to recur after removal.

Treatment.—In the first place this is prophylactic. Thus, in amputating, the flaps should be cut long enough to allow for their subsequent contraction, so that they may not become adherent to bone, etc, and the main nerves should be pulled down and cut short. A painful scar should be excised, and in an amputation stump it may be necessary to cut off a portion of the bone. When the nerves are "bulbous," the enlarged end and a considerable portion of the nerve must be exposed and removed. In some cases removal of a belt of periarterial sympathetic coat has relieved the causalgia of painful stumps.

MALIGNANT DEGENERATION

When malignant degeneration occurs in a scar or partially healed sore it is generally of an epitheliomatous nature. A chronic ulcer which thus degenerates becomes a hard, nodular, ulcerating mass, generally with much foul discharge, the edges of the ulcer being everted and raised above the level of the surrounding skin. The progress of the growth is usually slow; lymphatic involvement may be late, while the amount of pain is very variable. Treatment consists in free removal and closure of the wound by a plastic operation, or, in the case of a limb, in amputation.

STRETCHING

Many scars which at first are linear, narrow, and closely bind the neighbouring tissues become in time broad, thin, and only loosely attached to the adjacent structures. Sometimes this stretching is

beneficial; thus free mobility may be restored in a part where the scar caused limitation of the normal range of movement. Sometimes stretching of a scar has a deleterious effect, as when, after an abdominal operation, the scar yields to the intra-abdominal pressure and a ventral hernia follows. Scars of this kind remain covered with a layer of epidermis, and do not ulcerate unless the epidermis becomes very greatly thinned.

GENERAL PRINCIPLES OF PLASTIC SURGERY

The first essential for success in plastic surgery is that the parts to be operated on must be healthy and free from disease or inflammation. Secondly, the patient must be in good health, and not too old or too young. Thirdly, sound and rapid healing is most important; this means that primary union should take place, and therefore great care must be exercised to exclude sepsis. Failure of a plastic operation increases the difficulty and the chances of non-success of subsequent attempts, for scar tissue is never so satisfactory to use as healthy normal tissue. Operation in stages is often preferable to an endeavour to remedy the condition completely by one operation; disappointment frequently follows over-ambitious attempts.

As far as the skin is concerned, plastic surgery is practically limited to two methods—(1) the use of flaps, (2) skin-grafting.

Flaps contain subcutaneous tissue, as well as skin, to ensure their vitality. The incisions should be made parallel to the lines of the blood-vessels supplying the part, and should be curved rather than straight. The flap must not be scored nor button-holed; its length must be proportionate to the width of the attached base or *pedicle*. The latter must be sufficiently broad, and must not be twisted or unduly stretched. A flap may be *glided* from an adjacent part into the area it has to occupy; or it may be *transplanted* from a proximal or a distal part of the body, the pedicle being divided when union has taken place between the flap and the area upon which it is placed—that is, generally from about the tenth to the fourteenth day. The pedicle is replaced in the area from which it is raised.

Flaps may also be employed in other ways. They may be—(1) *Reversed flaps*, the cuticle being directed inwards and the raw deep surface outwards, and the latter covered by skin-grafts. (2) *Superimposed* or *double flaps:* two flaps are used, their raw surfaces being placed in apposition. The deeper of the two is a reversed flap, on to the raw surface of which is glided the superficial flap. (3) *Granulating flaps:* a flap is raised with a pedicle at each end, adhesions to the adjacent tissues being prevented by rubber tissue placed beneath it; its deeper parts are converted into granulation tissue. After

inch from each other. Each graft forms a centre from which the epithelium can grow over the raw area. This method is inferior to Thiersch's, but is useful when a very large area has to be covered.

3. **Wolfe's method.**—The whole thickness of the skin is included in the graft, which must be taken from a region of the body where hair is absent. In order to allow for contraction the graft is cut larger than the area it is to cover. Any subcutaneous tissue raised with the graft is removed before placing the latter in position. A few stitches may be used to fix the graft.

The healthy prepuce (which does not contain fat) removed by circumcision may be employed as a skin-graft. It should be divided into small portions before being applied to the raw area. It is not easy to sterilize, and it is liable to curl up.

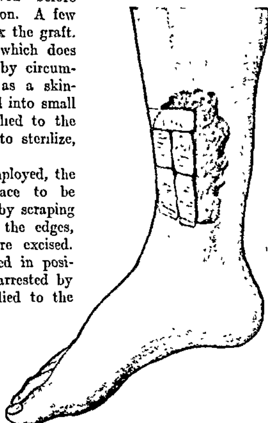


Fig. 780.—Thiersch's skin-grafts placed in position on a raw area.

Whichever method is employed, the granulations on the surface to be grafted must be removed by scraping with a sharp spoon; and the edges, if unhealthy and steep, are excised. Before the grafts are placed in position, hæmorrhage must be arrested by strips of gauze firmly applied to the raw area, a piece of protective being placed beneath the gauze so that the hæmorrhage shall not recur when it is removed.

A layer of protective (any strong antiseptic, such as 1 : 20 carbolic, used to sterilize the protective, must be removed by washing with sterilized salt solution) or perforated silver foil is placed over the grafts before the dressing is applied. A disadvantage of these methods is that the grafts are apt to become sodden if there is any sepsis present. The pressure of the bandage should be uniform, and a splint may be necessary to give the part the absolute rest which is essential. The dressing should be changed on the third or fourth day, unless there is a certainty of the wound being absolutely aseptic, in which case a week may elapse before the dressing is changed. In removing the dressing especial care must be exercised not to detach

the grafts; the protective may remain undisturbed if there is no pus beneath it. A valuable dressing is a layer of "leno" (an open-

solution. The leno is left *in situ* till the twelfth or fourteenth day, by which time the grafts should have secured a firm hold. Another simple method is to cut a piece of sterilized muslin, such as is used to make mosquito curtains, a little larger than the area which has been grafted, and fix it to the surrounding skin with collodion. The outer dressings are placed on this layer and can be changed as often as necessary. The mesh of the muslin is large enough to allow any discharge to pass through into the outer dressings, which are changed without disturbing the grafts

Grafts which are yellow, have a sodden appearance, and are bathed in pus and not adherent, are dead; a living graft has a pink or reddish colour, is dry, and is firmly attached to the tissues.

After a successful grafting, unless the part be carefully protected from injuries and from too early movement, the grafts will separate or degenerate. A prolonged rest, sometimes three to six months, may therefore be necessary to obtain a permanently good result. The surrounding skin should be attended to, and means taken to improve its nutrition. A bland thin ointment or an oily preparation should be kept on the grafted area to prevent any tendency to thickening or cracking of the epidermis.

DRUG ERUPTIONS

Skin eruptions may follow the administration of certain drugs used in surgical affections.

An erythema may follow the use of such drugs as belladonna, copaiba, cubebs, quinine, or the administration of an enema or of the various serums. The *copaiba* rash is a bright-red erythema which may be universally distributed, but is especially liable to show around the wrists and on the forearms It may appear quite suddenly, either after one or two doses, or when the patient has been taking the drug for some time. It causes a considerable amount of irritation. The *cubebs* rash is similar. An *enema* rash is a diffuse punctiform erythema of a bright-red colour which comes

petechial spots; the patient is generally ill. Inquiry should be made as to whether or not an enema has been given.

Serums not infrequently give rise to an intensely irritable urticarial or hyperæmic eruption, which usually appears a week or ten days after the administration.

Iodide and *bromide of potassium* may cause a pustular eruption like acne. Sometimes iodide produces large granulation masses with pus-formation; the masses burst, and the secretion, drying up, forms a scab on the surface. The face and limbs are the usual seats of the eruption, *which persists for* some time after the drug has been discontinued.

In unduly susceptible persons the use of *iodoform* in a wound may cause a bright-red erysipelatoid rash in the surrounding parts. (*See* p. 651.)

AFFECTIONS OF THE NAILS

ONYCHOGRYPHOSIS

Hypertrophy of the nails is not uncommon in old people, but may occur in younger persons. It is usually due to neglect in keeping the nails properly trimmed. The nail of the big toe is the one usually affected, but the others may show a similar condition in a lesser degree. The nail becomes *enormously thickened, rough and distorted, being twisted and bent into* the shape of a horn The free extremity may press on the adjacent toe or be curved towards the sole. Beneath the nail the matrix is thickened and there is often a large mass of epithelium.

Treatment.—In the minor degrees paring the nail after thoroughly softening it by soaking in hot water may be sufficient. In the majority of cases complete removal of the nail and its matrix is required.

INJURIES

CONTUSION

As a result of a blow on the nail an effusion of blood may occur between nail and matrix. When the effusion is extensive, separation of the nail is [illegible]

pair of scissors.

FOREIGN BODIES BENEATH THE NAIL

These are painful, and are liable to cause inflammation and suppuration; they should therefore be removed under nitrous-oxide anæsthesia as soon as possible. The affected portion of nail should be removed with scissors in order to provide a free exit for any exudation. An antiseptic dressing or hot fomentations should be applied.

INFLAMMATORY AFFECTIONS

ONYCHIA

This term is applied to inflammatory affections of the soft parts adjacent to the nail, or of the matrix. It occurs in several forms.

Acute onychia [illegible] is due to [illegible]

begins at one side and is [illegible] into the tissues at the base of the nail. The pus, accumulating between the nail and its matrix, causes loosening of the former and, in severe cases, death of the latter. Complete destruction of the matrix is followed by recovery

with absence of any nail; partial destruction, by the growth of an irregular, deformed nail or of an unduly thin one. The pain is often intense, although the amount of pus be small. The pus appears at the free extremity of the nail as thin yellow beads, and beneath the nail as a yellow streak replacing the normal pinkish-white colour. There is considerable redness and swelling of the surrounding skin. A not uncommon feature of the affection is its tediousness, a slowly spreading ulceration round the nail being produced, or repeated attacks of inflammation and suppuration occurring.

Treatment.—Any foreign body must be removed. Free exit for the pus must be provided as soon as possible. Unless the affection is limited to the actual finger-tip, a general anæsthetic such as nitrous oxide will be required, the operation being extremely painful. The loose portion of the nail, or enough to give free exit to the pus, should be removed. Hot boric fomentations are then applied and frequently changed. If recovery does not quickly occur, the part may be soaked in perchloride-of-mercury lotion (1 : 2,000) daily, or in some other efficient antiseptic lotion; but it must not be allowed to become sodden. Bier's method of congestion of the finger is also beneficial, and may be used in conjunction with other treatment.

As the patient may be out of health, a change of air is often beneficial; when the affection threatens to become chronic and gives rise to a persistent ulceration around the nail, injections of a vaccine made from the organism present should be tried. Silver nitrate may be used to destroy the granulation, its application is very painful for a time.

2. **Syphilitic onychia** occurs as an ungual or periungual affection in secondary syphilis.[1] The nails are also affected by congenital syphilis.[2] Primary syphilitic sores may occur around or beneath the nail. A chronic ulcer, with a small amount of discharge, which does not yield to ordinary antiseptic treatment, should suggest the possibility of a primary sore. Painless enlargement of the axillary or epitrochlear glands will aid the diagnosis. Spirochætes should be sought in the serum from the ulcer, and the blood tested for the Wassermann reaction.

3. **Tuberculous onychia,** also called **onychia maligna,** occurs in badly nourished children after an injury to the nail, and may affect several fingers, giving rise at first to a swelling at the base of the nail and involving the matrix. The swelling breaks down, and the nail is shed, leaving an indolent ulcer.

Treatment consists in removal of the nail if still adherent, scraping away all unhealthy granulation tissue, and applying iodoform gauze dressings, which should be kept moist. The general state of the patient's health must be attended to, especially with reference to its tuberculous aspect.

Other forms of whitlow are considered in the next article (p. 708) and on p. 525 of Vol. I.

Ingrowing Toe-Nail

This very common and painful affection usually affects the outer side of the big toe. It generally occurs in young adults, men more often than women, and in those who wear ill-fitting boots, who neglect cleanliness, and who cut the nail too short, especially at its corners. As a consequence the nail is pressed against the soft tissues.

Pathology.—The first effect is swelling and redness of the tissues adjacent to the free edge of the nail. Ulceration soon occurs, and a mass of unhealthy granulation tissue is produced, which extends gradually back-

[1] *See* Vol. I., p. 788.

[2] *See* Vol. I., p. 827.

cancellous exostoses. They push the nail upwards, and thus cause exposure of the matrix, giving rise to a good deal of pain and, if the exposed matrix is ulcerated, to a purulent discharge. *The treatment is to remove the nail* and the growth. The latter may almost shell out; if not, it must be completely removed with a gouge.

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MUSCLES, FASCIÆ, AND TENDONS

By E. ROCK CARLING, M.B., B.S., F.R.C.S.

Subcutaneous injuries.—The condition of the overlying skin affords no reliable estimate of the nature or extent of the injury inflicted on muscles by blows or crushing forces. The state of relaxation or contraction at the moment of impact, the relation of the muscles to bones, and the rapidity of the blow have an important bearing on the result, but are seldom accurately known.

SIMPLE CONTUSION

A muscle may be put out of action temporarily by a blow. The paresis is usually transitory, but may last for two or three days; when the disability is more prolonged it may be associated with partial atrophy, though without the electrical or sensory signs of concomitant nerve injury At the time of injury the part is tender to touch; passive extension, and active contraction when possible, are painful; irregular tremor of the muscular fascicles is often observed. There may be swelling from serous or bloody effusion.

Tendons are seldom injured by simple contusions, but bleeding into the tendon sheath occasionally occurs and may cause adhesions.

RUPTURE OF MUSCLES AND TENDONS

Rupture of healthy muscles and tendons may result from sudden forcible contraction, from sudden increase of strain when already in action, or from heavy impacts upon them when strongly contracted. In the last of these cases it is probably not so much the blow itself as the reactionary contraction which determines the rupture. The muscular substance may itself be wholly or partly torn; more commonly the muscle belly parts from its tendon. The tendon may separate from the bone at its insertion, and very rarely the tendon itself may break. The sheath of a muscle is generally, but not necessarily, torn; with many partial ruptures it escapes, on the other hand, the fascia alone may give way over an intact muscle.

The muscles most frequently ruptured are the rectus abdominis, the adductors, the biceps brachii, the quadriceps femoris, the sterno-mastoid, and the sural muscles With the exception of the biceps they are muscles with long bellies and short tendons

The *rectus abdominis* may be ruptured in an attempt to recover the balance; in vaulting to the saddle; or in an effort to lift too heavy a weight; during parturition, or by a heavy blow when firmly contracted. The rupture is almost always subumbilical. The *quadriceps femoris* is broken by precisely the same kind of strain as that by which the patella is fractured. The insertion of the quadriceps expansion into the patella yields more frequently than the muscle belly itself, the patellar tendon may be torn, or separated from its insertion The accident may be bilateral The *biceps brachii* (Fig 782) often suffers during efforts to catch or support heavy falling objects, or to catch at a hold when falling. The rupture is usually in the lower fourth, but may occur through the short or the long head. The *adductors* are frequently broken during the jumping exercises of cavalry recruits, though rarely torn in experienced riders. On the other hand, this accident is met with in swimmers under conditions that suggest fatigue as a predisposing cause. The *calf muscles* may be partly



Fig. 782.—Clinical appearance in case of rupture of biceps of some standing; the muscle actively contracted.

ruptured in springing, or by sudden active movements such as are required in tennis and other pastimes. Rupture of the *sterno-mastoid* occurs during delivery, by traction on the head in either direction. Some cases of so-called "sterno-mastoid tumour" originate thus.

Partial rupture, amounting in many cases to no more than the tearing of a few fibres or fascicles, is fairly common amongst gymnasts and athletes, especially in middle life. Muscles subject to occupational stresses, such as the neck muscles of timber porters and dock labourers, especially the muscles, fasciæ, and tendinous attachments of the sacro-lumbar mass, afford examples of these injuries.

Rupture of healthy tendons in their course is far from common, but detachment of the bony insertion is frequently seen, most cases involving the extensors of the fingers. It occurs, as a rule, from a blow on the tip of the extended finger, as in catching a cricket-ball. The little and middle fingers suffer most frequently.

Muscles may be extensively torn by the fragments of a fractured bone, by the displacement of a bone in dislocation, or by the forcible movements required for reduction. In machinery accidents very extensive damage to muscles and tendons may occur, but usually is overshadowed by the simultaneous involvement of more important structures. When parts of the extremities are torn off, such as fingers or toes, not uncommonly considerable lengths of tendon, and even of the terminal part of the attached muscle, are dragged out bodily.

In tetanus, delirium tremens, and mania, muscles may be ruptured, and "spontaneous" breakage in the course of ordinary movements may happen in senile or degenerate tissues. In enteric and other fevers, in hæmophilia, severe anæmias and scurvy, in phosphorus poisoning and jaundice, in arterio-sclerosis and albuminuria, in tabes and other diseases, hæmatomas are met with which result from ruptures, or lead to more or less laceration of muscular fibres.

The majority of tendon ruptures can be traced to some definite predisposing cause. Of 300 cases, less than 5 per cent. affected other tendons than the tendo Achillis, the patellar tendon, and the quadriceps expansion. The biceps, triceps, supinator longus, extensor longus and brevis pollicis, and the tibialis anticus, are among recorded instances. Chronic tendinitis and tendo-vaginitis, especially in association with osteo-arthritis, gummata of the tendons, tabes, and congenital anomalies, have been observed as contributory conditions.

In open wounds by edged tools or weapons, by projectiles, by fragments of glass or the like, muscles and tendons are frequently divided. The size of the skin wound may afford no indication of the actual damage, so that the nature of the lesion is often not recognized until after the skin has healed. Moreover, a tendon incompletely divided may yield subsequently.

Symptoms and signs of rupture.—At the time of the accident the patient feels a sharp pain at the site of rupture. Sometimes he is conscious that something has broken; sometimes he thinks he has been struck. Attempts at active or passive movement of the muscle give pain, which may be severe. Upon immediate examination, in spite of the tenderness it may be possible to feel a swelling, or perhaps two swellings with an intervening gap. If there be two, one is generally a good deal larger than the other; the gap soon fills with blood and masks the tumour due to the contracted and retracted muscle. Later, a soft "reducible" swelling is found in the course of the muscle, unaffected by passive extension. Voluntary contraction, especially when resisted, makes it harder and more prominent, draws it towards its attachment, and fixes it transversely. Somewhat similar signs, but less marked, are found with some partial ruptures. In the absence of localized swelling, and particularly where only a few fibres are affected, the diagnosis may be doubtful. The hæmorrhage may produce diffuse swelling, and the history may warrant a presumptive diagnosis, but in the calf, for instance, rupture of a deep vein and thrombosis may closely simulate fibrillary rupture. The fascia usually precludes subcutaneous ecchymosis.

In the case of ruptured tendons the diagnosis is made almost entirely upon the defect of function. There may be some effusion of blood in the course of the tendon sheath, but it is not constant. When only one of several tendons acting in the same general direction is affected it may be difficult to establish the fact of rupture or division.

Treatment.—In such a partial rupture as occurs in the gastrocnemii in so-called "tennis-leg," firm bandaging and postural relaxation on a couch should be maintained for ten days, when tentative efforts at walking may be permitted. If the damage is quite slight it is enough to strap the leg in overlapping layers from below upwards, and to allow walking on the flat sole from the second or third day. Massage of the effleurage type is useful in relieving pain and promoting absorption For rupture in the sacro-lumbar muscles, broad strips of strong strapping applied all the way up the back after passive relaxation afford great relief, but the prone position is sometimes advisable for a time.

When the hæmatoma is large, rest must be maintained until absorption is almost complete. In the hours immediately following the accident, cold or evaporating lotions, with or without compression by an open-wove bandage, are useful. If absorption of the blood-clot is delayed, or if the clinical indications point to a severe or complete section of an important muscle, the clot should be turned out and the muscle sutured with catgut or kangaroo tendon; silk is not so well tolerated in muscle. The sutures must be deeply passed, and

some of them should be of the mattress type, as considerable tension is often necessary; single sutures in the line of the *fasciculi* have but an uncertain hold.

Longitudinal wounds of muscle require no treatment beyond that imposed by surgical cleanliness; if lacerated and begrimed, the damaged parts should be excised and a few points of suture inserted. It is important to close the fascia carefully. Drainage will or will not be provided in accordance with general surgical principles

When the part to be operated upon is below the rib margin, spinal anæsthesia is preferable on account of the perfect muscular relaxation.

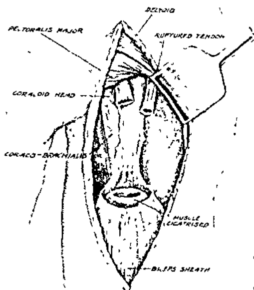


Fig. 783 —Case of rupture of biceps (operated upon by A. H. Tubby).

In operations upon old-standing muscle ruptures considerable difficulty may be experienced in exposing and freeing the retracted muscle tissue, but it must be done if a good functional result is to be obtained. (Fig. 783.) It may be necessary to elongate the muscle by plastic incisions, or to make use of adjacent fascia to re-establish good functional attachment. The wound must be left dry, and it is advisable to keep the parts at rest for a week or ten days before commencing massage.

A tendon detached from its insertion may be sutured to periosteum or fixed by a strong suture passed through a hole drilled transversely in the bone. Large tendons ruptured or severed in their course are approximated by relaxation sutures and the surfaces adjusted by fine stitches. In the case of tendons running in definite sheaths, difficulty may arise from wide retraction. In longstanding cases it may be necessary to form an artificial tendon of silk or fascia, to graft the distal end into an adjacent tendon, or to split a companion

tendon and utilize a portion to reach the insertion of the one divided.

HERNIA OF MUSCLE

In this condition protrusion of healthy resting muscle occurs through a fascial defect, which may be congenital or may result from wounds, or *possibly from repeated contusions. In certain circumstances, though the* volume of a contracted muscle is not greater than in relaxation, violent muscular effort may rupture the fascial sheath. The hernia presents as a soft depressible lump, which disappears on passive extension or opposed contraction. Often it gives no trouble, but may cause pain, impede movement, or lead to rapid fatigue. Hernias usually appear in the rectus femoris, the biceps, the adductor longus, and the muscles of the forearm. Among soldiers hernia of the tibialis anticus seems to be common. Nearly all recorded cases have been in adult men.

If treatment is necessary the gap in the fascia should be obliterated by simple suture, or by a gliding flap of fascia, or by darning with catgut.

LUXATION OF TENDONS

Luxation only occurs in those tendons which pursue an angular course, whether normally, as in the case of the peronei, or in association with deformities. Congenital anomalies or senile or inflammatory changes in the fascial sheaths or retentive bands and ligaments, callus filling bony grooves, bony outgrowth, or absorption associated with joint diseases, are potent predisposing causes. The only normal tendons commonly dislocated are those of the peronei. It is said that some persons can even luxate them voluntarily over the malleoli. In general the displacement results from a sudden violent contraction of the muscles when the foot is abducted. There is sharp pain with immediate disablement Examined at once, the tendons may be felt coursing obliquely across the malleolus, but swelling and tenderness soon make the investigation difficult.

After reduction, which is usually easy, fixation of the foot in extension and adduction results in temporary relief, but recurrence is the rule. Such recurrence is occasionally attended with little inconvenience, but it is usually crippling, and operation is necessary. The retinacular bands are found torn, and, if the luxation has been extant for a few weeks, the grooves may be found partly filled with granulations or completely obliterated. A new groove should be made by dissection or by gouging the bone. Where material is available, it is sufficient to repair the ligamentous sheath by suture, but it is often necessary to turn down a flap of periosteum, or periosteum and bone, from the malleolus and fasten it to the os calcis. In this way a permanent result can be assured Other tendons that have been dislocated are the anterior and posterior tibials, the long extensors of the thumb and index, and the long head of the biceps

Displacements of the popliteus, the pronator radii teres, the splenius capitis, and other muscles have been described The splenius is said to get hooked over a prominent transverse process of a cervical vertebra during sharp turning of the head.

MYOSITIS

The clinical term "myositis" covers the affections of muscles dependent upon infective agencies or circulating poisons, and is

extended to embrace the degenerations met with not only in association with inflammatory conditions, but also as a result of trauma, circulatory disturbance, and hitherto less-defined causes.

Etiology.—All the common pathogenetic organisms have been met with in muscle infections. *Some forms of myositis, however,* appear to be due to poisons introduced from without, such as alcohol, or to noxæ elaborated in the intestine or produced by disordered metabolism.

The muscular tissues proper are not very susceptible to direct infection, and their fibrous sheaths protect them from a great many local extensions of suppurative processes. Nevertheless, myositis is met with in the proximity of such lesions as appendix abscess, pleurisy and empyema, suppurative arthritis, acute adenitis, cellulitis, and the like. In pyæmic states abscesses are occasionally met with in the muscles themselves, but more often the actual site of suppuration is the connective tissue between muscles and their sheaths or between adjacent sheaths.

Myositis occurs in the course of, or as a sequel to, specific fevers such as enteric, smallpox, typhus, cholera, and possibly scarlet fever and measles. It also results from invasion by such parasites as *Trichina* (or *Trichinella*) *spiralis.*

Saccharolytic anaerobes (e.g. *B. welchii*, *B. perfringens*) find in muscle, which is rich in carbohydrate, a most favourable nidus for their development. In war wounds, muscle tissues are extensively lacerated and pulped and their blood supply is cut off; it is devitalized muscle-fibres that are most readily, or alone, invaded; hence the predominance of the muscles in the local clinical picture of gas gangrene. The proteolytic anaerobes (*B. histolyticus*, *B. sporogenes*) develop more slowly than the saccharolytic, which often require but a few hours. Hæmolytic streptococci prepare the way for and favour the activities of the anaerobes.

Pathology.—The naked-eye aspect of the muscles in myositis varies with the severity of the process and the stage reached. They may appear simply sodden, or as if steeped in slightly turbid fluid; in diffuse infection they are pale, grey, and lustreless; turbid serum or pus exudes from the interstices; there may be fetid masses of slate-grey or greenish slough; local abscesses have dirty-white, brown, or blackish walls, which are shreddy and irregularly excavated; there may be sanious or creamy or yellowish-green pus, perhaps with foul gases, exuding from the tissues. Degenerate muscle is pallid, fragile, opaque, streaked with yellow or brown, or so far converted into fat as to appear like a mass of rather dry and fibrous adipose tissue; frequently there are points of hæmorrhage.

In the mildest cases the microscope shows a simple œdema; in

more severe inflammation the exudate is highly fibrinous. Leucocytic infiltration is accompanied by varying degrees of proliferation of the nuclei of the perimysium and of the connective-tissue cells in general.

The muscle-fibrils proper suffer almost entirely secondarily; striation is early lost, and discoid separation and longitudinal fragmentation are often observed. Vacuoles appear in the parenchyma, the fibrils are swollen, hyaline-looking, unstainable, or converted into or obscured by droplets or masses of fat.

In **gas gangrene** the organisms spread in the connective-tissue reticulum between individual fibres, which become isolated from their sheaths by toxic fluid, and only then are invaded and destroyed. Infiltration by this toxic fluid occurs in advance of the gangrenous periphery, separating the fibres longitudinally, and thus determining the spread, so often seen, along one muscle of a group, from end to end. The nuclei of the sarcolemma disappear late in the course, which may, however, run on to complete destruction with abundant gas-formation in from six to twelve hours.

Leucocytic invasion of muscle-fibres is seen only where spread is being arrested; there may then be active phagocytosis of the bacilli. (*See also* the Section on Gas Gangrene, Vol. I., p. 258.)

Inflammation of muscle may result in complete *restitutio ad integrum*, in suppuration or sloughing; there may be terminal atrophy or fibrosis with various forms of degeneration of the contractile elements These have been described as *cloudy swelling*, met with in general febrile states; as "*vacuolar*" degeneration, which in chronic œdema may go on to colliquative necrosis; *vitreous, hyaline*, or *granular*, met with in sepsis, intoxications, and as a result of trauma, burns, freezing, and pressure atrophy; *lardaceous*, seldom, if ever, seen in muscle, though it has been described in the tongue in association with general toxic absorption; *fatty*, which may be a mere infiltration or a true degeneration, and is seen at a maximum in conditions of defective innervation.

Necrosis occurs in severe infections, where the toxins are of high virulence and the exudation and infiltration are so great as to interfere with the circulation in the larger vessels; it is found also in burns, freezing, arterial sclerosis, and prolonged or severe compression.

Proliferation of the connective-tissue elements not infrequently leads to extensive fibrosis, with compression-atrophy of the parenchyma or possibly fibrous metaplasia. Calcification sometimes follows upon the degenerations or fibrosis.

Diagnosis.—Recognition of the muscles as the anatomical site of an inflammatory lesion is by no means simple. It has been seen that the superficial parts are very often involved, so that, for example, a polymyositis of obscure origin has been mistaken for an angio-

neurotic œdema. Such an error can usually be avoided by attention to the associated constitutional signs, the fever, anorexia, and so on. Superficial brawny swelling and great tenderness may make it very difficult to feel accurately a hardened muscle beneath; mere disinclination to use certain muscles, or spasm and rigidity of muscle groups, is more often an indication of extraneous mischief, such as disease of joints or bones; again, the muscles spasmodically contracted, and therefore palpable as harder masses, may possibly be but a reflex indication of inflammation in another muscle or another tissue requiring protection. Discrete inflammatory lesions, such as a gumma, a tuberculoma, or even an abscess, may be recognizable as to site, from their anatomical position, and from the alterations in position and consistency with contraction of the muscle or muscles, but impossible to diagnose as to pathogeny, since tumours such as lipomas, cysts, discrete angiomas, and even sarcomas, simulate them, and one another. Close attention must be paid to the history or signs of antecedent or coincident infection, local or general. The various serum and cuticular reactions must be used in obscure cases. The blood-count may give assistance, as, for instance, by the eosinophilia of trichinosis; a biopsy may be justified. In many cases it is merely a question of recognizing that the muscles have become involved in an already obvious disease.

In pyæmia, tuberculosis, syphilis, acute articular rheumatism, or gonorrhœa the diagnosis is generally already made when the muscles become affected; but in glanders, for example, the predominant share of the musculature may be a point in differentiating the condition from other forms of bacteriæmia.

In the mildest cases of myositis, where local signs are minimal and pain the only complaint, diagnosis is simply a matter of exclusion.

The **clinical characters** of the various forms of myositis are dependent upon the nature, virulence, and mode of access of the toxins or organisms concerned, and upon the capacity of the defensive agencies of the tissues. The symptoms may be referable solely to the affected muscle, but where many muscles are involved, or where the muscular lesions are only part of a wider infection, the general state may submerge the mere local signs. The muscle or group of muscles is swollen, tender, and painful. The overlying skin and soft parts may show soft or brawny œdema; urticarial and erysipelatoid rashes sometimes accompany the widespread forms. Both active contraction and passive extension are painful; the part may be held rigid with the inflamed muscles relaxed. Where the muscle concerned is deeply placed or beneath strong fascia, suppuration may occur, and free fluctuation over a considerable area be the first observed sign. In mild cases the objective signs may be limited to a hardness, a

diffuse or local induration of the muscle, to fixity of posture and functional disability.

Treatment of myositis is mainly symptomatic. Pain may be relieved by such drugs as sodium salicylate, aspirin, potassium iodide, heroin, or morphia. Confinement to bed is advisable in severe cases, even when not dictated by other considerations. Something can be done by posture, by supporting splints or pillows, by hot or cold applications, by gentle effleurage with the hand, or with a roller attached to the anode of a galvanic battery. Turkish baths, static and vibrant electricity, and cataphoresis are useful. In the more acute forms, congestion hyperæmia by local hot air or by constriction should be given a trial, and in appropriate cases serums and vaccines are valuable resources. When suppuration or sloughing occurs, free incisions should be made and drainage provided. A muscle invaded by anaerobes and becoming gangrenous should be excised in its entirety, if possible.

The effects of atrophy and fibrosis must be prevented as far as possible, and deformities treated by tenotomies, division of muscles, or mechanical apparatus

Rheumatic myositis.—The term muscular rheumatism is used in rather a loose way to designate muscular pains of uncertain origin It is probable that the muscles play only a contributory part in the production of such conditions as "stiff-neck," "pleurodynia," and "lumbago," the fascial planes and the nerve terminals, or even the nerves themselves, being equally or primarily involved. The relation of onset to "chill," exposure to damp and draughts, the comparative frequency of occurrence in those of rheumatic tendency or inheritance, or as an alternative manifestation with arthritis, are held to justify the designation. Whilst chronic or recurrent myalgia thus occurs in rheumatic subjects, it is met with also in those who have never exhibited any articular or cardiac manifestations of the disease, and may be dependent on other toxins. In all cases after repeated or prolonged, though mild, attacks of pain without local signs, hard swellings or nodosities may be found in the course of the muscles, and these often lead eventually to contracture and possibly to restriction of mobility or actual deformity.

In association with acute articular rheumatism definite myositis is observed. The muscles are swollen and indurated, the overlying skin œdematous. In some instances muscle excised in these conditions has proved normal on histological examination, but occasionally diffuse œdema, acute congestion, and sero-fibrinous exudate have been found. The majority of cases recover completely, but in the most severe attacks, especially when the same muscles suffer repeatedly, atrophy may be marked. Suppuration never occurs.

Gonorrhœal myositis is similarly related to the arthritic manifestations of the infection. In some cases there is a mere myalgia, but in others there is definite myositis characterized by dense cellular infiltration which leads to extensive fibrosis. Actual suppuration is rare, but when it does occur a pure culture of the diplococcus may be recovered.

Polymyositis.—The term primary acute polymyositis has been applied to certain cases, of which there are now a good many on record, characterized by severe non-suppurative inflammation of many muscles.

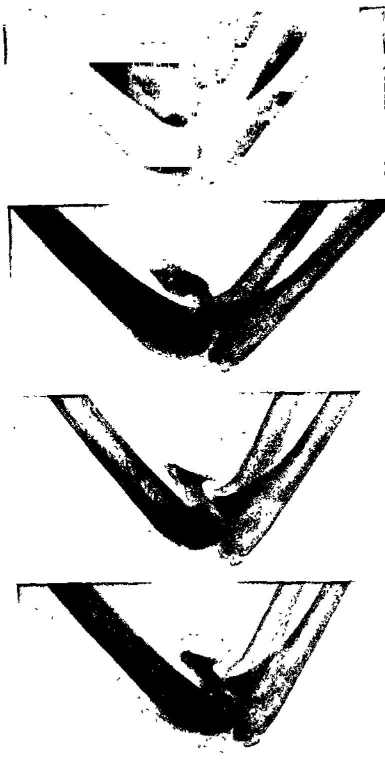
Etiology and pathology. — Careful bacteriological examinations have failed to detect any organisms, and although the spleen has generally been found enlarged, necropsy has disclosed no visceral or other focus of infection. In the absence of positive evidence it is presumable that the causative agent is an intestinal toxin.

The onset may be gradual or abrupt, without special reference to antecedent illness. In quick succession many muscles are involved, those of the tongue, the back, and the extremities especially. None of the striped muscles are exempt, and in the fatal cases it is to the involvement of the respiratory muscles, with consequent inhalation pneumonia, or of the cardiac muscle, that death is due. The muscles are hard and rigid, extremely tender, and so painful that the patient lies immobile in bed. Some cases are attended by stomatitis and other indications of alimentary catarrh. Urticarial and erythematous rashes are common, and brawny œdema is [illegible] . hence the term "dermato- [illegible] some cases there is an ery- [illegible]

In a few cases the disease runs an acute course throughout, and may terminate in ten days or a fortnight; but usually the acute symptoms abate and the course is protracted, dragging on for weeks or months, irregular fever indicating an intoxication that is, however, accompanied by little emaciation.

The muscles appear brownish-red or waxy, and show areas of localized colliquative change which yield a thin turbid fluid or grey detritus. The muscle fibres are found dissociated, infiltrated by round cells, with here and there areas of disintegration; the nuclei are fragmented. Deposits of pigment are common.

Whilst cases conforming to this type are well recognized, there is no hard-and-fast line to be drawn between them and others in which micro-organisms, most often staphylococci and streptococci, have been cultivated from the muscular lesions, or in which necropsy has revealed some distant focus of infection, such as pus in the middle ear, a nasal sinus, or elsewhere. On the one hand there are cases in which, as a sequel to a carbuncle or boils, an abscess, or some other-local infection, single muscles, or groups of muscles, exhibit the signs of myositis, and eventually become atrophied or undergo fibrous contracture. On the other hand are the severe and almost invariably fatal cases in which the clinical picture is that of pyæmia. There are cases in which some of the muscular foci suppurate and in which, nevertheless, recovery ensues. That is the case, for instance, in typhoid fever; but it may be so with any other infection. Absolute distinction is impossible between the cases due to a true bacteriæmia and those dependent on the circulation of bacterial toxins. Some cases of alcoholic neuritis are accompanied by polymyositis, and there are other types of "neuro-myositis"



From a case of intramuscular osteoma following dislocation of the elbow; taken at successive intervals of about three months. The mass was freely movable transversely, at first.

PLATE 130.

in which to the muscular symptoms are added sensory disturbances, palsies, and derangement of the electrical reactions.

A mild type is met with in connexion with erythema multiforme and erythema nodosum.

Myositis fibrosa progressiva is a rare disease, coming on in childhood and leading to extensive bodily deformity. The muscles are slowly transformed into dense fibrous tissue of tendinous type. Subacute at onset, the course is exceedingly chronic. A few cases of recovery are reported, and it is possible by persistent massage, faradism, and mechanical treatment to arrest the disease or avert deformity in some measure.

[illegible] **essiva** appears in infancy or child- [illegible] in early adult years by some inter- [illegible] current acute or subacute attacks, in which tender, doughy swellings appear in the muscles, to subside gradually, some disappearing altogether, others developing into dense bosses, or plaques, in which bony spicules, sheets, or arborescent masses are ultimately formed. The broad musculo-fascial planes of the back are usually first attacked, but the osseous formation affects all muscles except those of expression, the tongue, diaphragm, heart, sphincters, and muscles of deglutition. In the late stages all bodily movements may be abolished and mastication impossible. The disease is commoner in males than in females, but no hereditary influence is observed. Microdactyly and a peculiar stunting of the great toes have been noted in a number of the sufferers. Muscle excised in the early stages exhibits definite evidence of myositis, but no information is forthcoming as to the causative agency. All stages of the development of true bone have been observed. [illegible] but the connective tissue undergoe [illegible] Many of the masses of bone, thou [illegible] are not connected directly to the skeleton, but others develop in the attached parts of muscles or eventually reach the bones. Whereas the free masses of bone serve to distinguish the condition from that of multiple osteomas, yet in the latter disease the disturbance of growth at the intermediary cartilage may be so extreme as to lead to the development of sheets and spicules of bone in the fibro-muscular planes which closely resemble the fully formed masses in myositis ossificans There are, moreover, cases in which the progressive formation of bone in many muscles occurs, or is observed, for the first time in adult life, and in which the cause of the originating myositis is equally obscure.

The term **traumatic myositis** is sometimes applied to describe the processes incident to repair after injury, and also to an acute inflammation, often suppurative, which affects chiefly the psoas or some other large muscle like the deltoid Fatigue, overwork, and strain undoubtedly predispose to myositis when there is a distant focus of infection. When suppuration occurs the staphylococcus aureus is often found in the pus.

Myositis ossificans traumatica (muscular osteomas).— Besides the formation of bone in the tendinous attachments of muscles that are the subject of occupational stresses, and about foreign bodies such as pieces of glass, needles, or ligatures, considerable masses are sometimes found in the substance of muscles after trauma When this development follows upon fracture or dislocation (Plate 130), it is probable that bone-forming elements have been displaced and implanted in the muscle. Similar masses result, however, in rare instances from simple contusion or wound of muscle without clinical or X-ray evidence of injury to the

skeleton. They are most often found in the quadriceps or brachialis anticus, but isolated examples have been reported in other muscles. Definite bony characters appear in about six to twelve weeks. The bone may be all compact tissue, or partly cancellous, and has well-formed Haversian canals. Cartilage is sometimes seen in process of ossification. The masses are not very painful or tender, as a rule, but lead to weakness, aching, and ready fatigue. Their increase in size may lead to a suspicion of new growth. Operation is only required if from their position or bulk they impede the movement of a joint, or if they occasion much loss of power from fixation or associated atrophy of the muscles It is inadvisable to operate until radiograms show a definitive size, when the masses can be excised entire with a little adjacent tissue. The wound must be left perfectly dry. Too early operation is likely to be followed by recurrence, especially if blood is left in the cavity, and, moreover, even when radiograms have shown definite bone, considerable diminution in size is sometimes observed. So long as there is no increase in size, massage is useful not only to restore the tone of the surrounding muscle, which is usually wasted, but also to promote absorption. The effect must be carefully watched.

Tuberculous myositis is almost invariably a simple extension of the infection from adjacent parts, bones, joints, glands, or other tissues. Rarely it may be primary; that is to say, of hæmatogenous origin

The focus may be solitary—a tuberculoma, a pink gelatinous or caseating mass, with fibrous or calcareous surroundings, or breaking down into purulent detritus. Such an "abscess" may be met with in the tongue, without any accompanying lesion of the mucosa; or in a muscle of the extremities. In other cases muscles may be the seat of numberless isolated or contiguous tubercles; one muscle alone may be affected throughout its whole length, or a group of muscles may be involved in irregular spread. Fistulæ may form, and fungous granulations show on the surface, or scrofulodermia may result.

Diagnosis is difficult only in the isolated cases, but may then be impossible. The intramuscular mass may be mistaken for a lipoma, a cyst, an angioma, or, if it have reached the fascia, for a pseudo-hernia.

The diffuse process has sometimes a nodular character, which may suggest a differentiation from other forms of myositis.

If active treatment be required, the affected tissue should be freely and widely excised, even if it involves removal of the entire muscle. If this be done, it may be advisable to transplant the tendon to an adjacent muscle Where excision is impossible, simple incision, with scraping, leaving the cavity full of iodoform emulsion, may suffice. The general treatment is that of tuberculosis elsewhere.

Syphilitic myositis.—In early syphilis the limb muscles, the erector spinæ, and the fronto-occipitalis may show a simple myalgia. The pain is constant, and is worse at night.

Two forms of myositis also occur: (*a*) A diffuse interstitial inflammation appears either in the first year, or about the third or fourth after infection. The insidious onset is heralded by slight cramps, while the muscles gradually become stiffer and more painful. For a *time they remain mobile up to a certain point, but may become* quite inextensile. The biceps and sterno-mastoid most often, but the hamstrings, quadriceps, pectorals, deltoid, masseters, and sphincter ani also, are attacked. There is a fibrinous exudate into the muscle bundles; the vessels are dilated and thickened; the muscle nuclei proliferate, and with them the connective-tissue cells, so that there may be extensive atrophy of the muscle cells; as a rule, striation is preserved. The lesions are occasionally symmetrical. The course is protracted, but recovery of function is frequently very satisfactory if specific treatment is pushed.

(*b*) Gummatous myositis may take the form of an isolated syphiloma, or the gumma may be combined with a more diffuse process (Fig. 784, B.) An isolated gumma occasions but little pain or disability. An indolent lump, generally in the middle of the muscle belly, is felt, not always strictly limited to the borders of the muscle. Gummata are common in the tongue and the sterno-mastoid, but may affect any muscle; they have been found in the levatores ani.

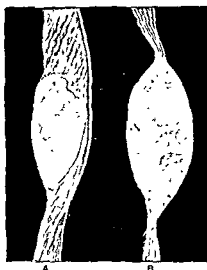


Fig. 784.—A, Secondary sarcoma in rectus abdominis muscle. B, Part of gastrocnemius muscle in the substance of which is a gumma, quite circumscribed but not encapsuled.

(*Westminster Hospital Museum, Nos. 382 and 380*)

Gummata sometimes occur in muscles as a very early tertiary lesion; they have been recorded as late as the thirtieth year after infection. In the inherited form they may be manifested as late as the twentieth year of life, but the sterno-mastoid cases sometimes appear within the first few weeks after birth.

Treatment is that for the disease; mercurial inunction over the affected muscle combines the influence of massage and movements with the specific effect. If a gumma breaks down, the resulting ulcer must be preserved from secondary infection.

Glanders and **actinomycosis** both affect muscles. They are described in Vol. I., at pp. 904 and 910 respectively.

TENDINITIS—TENO-CELLULITIS—TENO-SYNOVITIS

Inflammatory lesions of tendons so constantly involve the surrounding connective tissue that no separate description is required. When the peritendinous tissue is definitely differentiated as a "sheath," the physical signs may be roughly confined to its narrow anatomical limits, and the pathological phenomena are those characteristic of serous membranes. The initial congestion and œdema of the innermost layers of the sheath so alter the smooth alinement of the superficial cells that the usual frictionless play of the tendon within is impaired. Transudation of fluid into the space between the tendon and the wall quickly follows. Upon the nature of this exudate depends the subsequent development of the case. A simple serous fluid is absorbed and recovery is complete; a sero-fibrinous exudate is not incompatible with such a result, though longer delayed; but, on the other hand, it is likely to be attended by the formation of adhesions. In the presence of organisms, such as *the staphylococci and streptococci, the pneumococcus and typhoid* bacillus, suppuration is the natural sequence. In mild cases the tendon itself suffers little if any change. In the more acute and *destructive forms it loses its glistening appearance, appears dull and* swollen, the tendon bundles are infiltrated with leucocytes, and the superficial parts exfoliate. Considerable masses may necrose, and when they do so separation is often a tedious process. In other cases the tendon surface becomes vascularized, beset with bud-like granulations, which fuse with similar formations upon the now velvety or finely mamillated inner aspect of the sheath. The result may be so close and complete a union as to abolish all movement. In the presence of pus the process does not remain indefinitely within the confines of the sheath; extension occurs both directly and by way of the lymphatics, so that spreading cellulitis results. In the case of tendons without well-formed sheaths the process is, from the outset, of the nature of a cellulitis.

The simplest form of **teno-synovitis** is attributed to excessive use, and there is evidence that a prolonged spell of constantly repeated muscular contractions, especially when continued beyond the point of fatigue, is the determining factor. In many cases the exertion, if extreme, is nevertheless habitual, and some other factor must be involved.

A single sudden severe strain is sometimes responsible for an affection of the tendon and its surrounding tissue, which is more persistent than is usual with the effects of trauma. It may be seen, for example, in the tendo Achillis after a jump from a height, in the wrist of a golfer who has checked his stroke, in the fore-

arm of one whose grip may have been subjected to the surprise stresses of motor-buses; and the interval elapsing before the appearance of symptoms may exclude mere tearing and detachment as the explanation.

Although teno-synovitis is not very common in association with acute articular rheumatism, yet the simple form generally yields to "anti-rheumatic" remedies, and occasionally moniliform thickenings of tendons are met with under conditions analogous to those in which rheumatic subcutaneous nodules occur. The gonococcus and its toxins are responsible for a similar but rather more severe type of the affection, chiefly as an accompaniment of the articular lesions, but rarely as an independent manifestation, and then, it may be, very soon after infection.

The symptoms have an abrupt onset with pain which rapidly increases in severity but is elicited only by movements of the tendon. In the intervals there may be some dull aching or complete relief. The most striking sign is a well-marked creaking, easily perceived by light palpation of the parts during active movement of the tendon. It is generally attributed to friction of the inflamed surfaces before there is enough fluid exuded to separate tendon and sheath. It is to be felt, however, over tendons that have no sheaths, and often is not limited to the immediate course of the tendon, being more nearly annular in distribution. The exudation pervades all the peritendinous connective tissue and the overlying fasciæ, so that the names "peritendinitis" and "metadesmitis-crepitans" have been proposed as more appropriate. When there is much serous exudate there may be diffuse or discrete swelling: the skin may be reddened and even œdematous; but in uncomplicated cases there are rarely any constitutional signs.

In the worst cases, and particularly those of gonococcal origin, there is often reflex spasm of the muscles, but it is not so marked as that seen in cases of gonorrhœal bursitis, with which, however, peritendinitis may be associated.

Treatment.—The first essential in treating simple synovitis is rest. If absolute rest is out of the question, relative immobility by firm bandaging over a mass of cotton-wool, or strapping, will suffice. Neither hot nor cold applications do much good, but counter-irritation by iodine, and friction with stimulating liniment, are useful. The salicylates in some form should be pushed, since they generally afford rapid relief. In the gonorrhœal form rest only should be employed in the early stages. Iodide of potassium is probably the best drug to administer. As soon as movement can be borne, gentle manipulation through the complete range of movement of the tendon should be employed once or twice daily, to prevent adhesions as far as possible.

Persistent massage should be ordered as soon as the clinical signs of inflammation have disappeared.

Acute suppurative teno-synovitis, *or* ***thecal whitlow,*** is due to infection of the sheath by direct injury, by extension from the subcutaneous tissues, the periosteum or the bone, and rarely by the circulation. In its typical form it occurs on the palmar aspect of the hand. Pus spreads rapidly along the sheath as far as it extends, and makes its way into other sheaths and communicating spaces At first the pus within the firmly resistant but highly vascular walls is retained under considerable tension, so that absorption is intense and constitutional signs are severe. The infiltration of the walls may be so acute and the toxins so virulent that necrosis occurs, and the pus finds its way unrestrained among the tissues, setting up a diffuse cellulitis.

In the course of the tendon there is a tense, exquisitely tender swelling; the skin is [illegible] parts are œdematous [illegible] ments are carefully [illegible] can sometimes be modified by posture; attempts at passive movement elicit agonizing, lancinating pains. Fluctuation may or may not be obtained.

Treatment is beset with difficulties. The pus must be evacuated at the earliest possible moment, but in the hand, the commonest situation for the affection, great care must be exhibited not to damage nerves or to open up planes of tissue hitherto uninfected. To make sure of saving the tendon, a sheath should be opened up along the whole length of the infected portion; this procedure, however, permits escape of the tendon; as the wound heals by granulations its replacement is almost impossible, and functional defect is inevitable. The use of multiple small incisions, thorough irrigation, and ample drainage is therefore preferable. It is usual to make the incisions exactly in the median line of the sheath, but in the fingers incisions on both lateral aspects give good results. It is in this affection that the use of Bier's hyperæmic method finds one of its most useful applications. After multiple small incisions without drainage, a suction apparatus adapted to the part and applied at intervals often effects rapid resolution. If drainage is employed there is no treatment so satisfactory as a continuous bath of boric acid, hydrogen peroxide, or some similar mild antiseptic solution. In the intervals between the baths, large enveloping boric fomentations are applied. As soon as the condition of the wounds permits, systematic massage must be begun; it is a good plan to combine it with soaking in hot water or with hot-air baths. A splint may sometimes be advisable to prevent deformity.

Chronic teno-synovitis occurs as a sequel of the simple acute type, as a result of trauma—especially fractures about the wrist and ankle—in association with osteo-arthritis, or with gout, and in the special forms to be described subsequently.

In some cases there is merely a persistent distension of the sheath by serous fluid, giving rise to little inconvenience. In others a plastic exudation leads to obliteration of the space between tendon and sheath, or to matting of tendons and peritendinous tissues, or to the formation of fibrous nodules and local thickenings. In yet others a hyperplasia of the inner layer of the sheath, with the formation of redundant fringes and vascular papillomatous processes, is associated with attenuation of the fibrous outer layer so that dislocation of the tendon may result. Rarely the hyperplasia results in the development of masses of fatty tissue.

The great majority of cases of chronic teno-synovitis are, however, due to *tuberculosis*. The infection may be hæmatogenous, be propagated from adjacent bones or joints, or rarely be implanted. The sheath is generally considerably thickened. The innermost layer is beset with granulation tissue rich in histological tubercles; giant cells are numerous, and the vessels show endarteritis and periarteritis. This aspect of the sheath, and sometimes the surface of the tendon too, is velvety or finely villous, or studded with fibrinous deposits. The outer layer is the seat of reticular tubercle and hyperplastic fibrosis. In some instances there is considerable effusion of thin turbid fluid containing flakes of lymph; rarely the contents of the distended sheath are of a creamy purulent character. Frequently the whole cavity may be stuffed with the peculiar pearly ovoid bodies known as "melon-seed" or "rice" bodies, the exact origin of which is a matter of dispute, and is probably not always quite the same. Some are laminated and appear to be derived from successive deposits of fibrin, but many betray traces of a pedicle and have apparently been attached to, if not an integral part of, the villoid lining membrane. Tubercle bacilli have been found in them. Their ultimate shape is due to friction. The granulations are sometimes so exuberant as to lead to the description of a "fungous" type of the disorder, in which a pulpy mass invades the surrounding tissues and reaches the skin, giving rise to persistent sinuses.

The tendons on the flexor aspect of the wrist are those most frequently affected, but the peronei and the extensors of the toes and fingers do not escape, nor, indeed, are any tendons entirely exempt. The years from 18 to 35 include the bulk of cases, but infancy and advanced age are not free. Previous attacks of inflammation, especially if gonorrhœal, help to prepare a suitable nidus for the tubercle bacillus. Of insidious and almost painless origin, the condition attracts attention

either by an obvious swelling or by the weakness, tiredness, or aching it occasions. The swelling, as it affects the front of the wrist, is more or less hour-glass-like in shape, being constricted where the common sheath passes under the anterior annular ligament. When other tendons are affected there is in the course of the tendon a fluctuant swelling, which is but little if at all tender, and seldom involves the skin. When rice bodies are present, active movements of the tendons, which are rarely materially restricted, impart to the palpating hand a distinctive crepitant sensation. In the fungous type the sinuses overlie a semi-solid, puffy mass, and have at the edge the pale, flabby granulations common to tuberculous sinuses elsewhere.

Tuberculosis of the tendon sheaths about the ankle is usually part of the same process in the tarsus, and is recognized from the spread and distribution of the general swelling rather than from signs peculiar to the tendons.

Treatment, in the first instance, should be by rest in splints or removable cases, by strapping with some mercurial ointment, or by congestion hyperæmia. Unless such measures produce notable improvement within a few weeks, and can be backed up by proper hygienic conditions, operation should be advised. Of course, where there are already sinuses it is imperative to cleanse them, and then to deal with them radically.

The distended sheath should be laid open, if necessary, along its whole length, though two or more short incisions generally suffice. The contents should be evacuated by systematic gentle scraping and dissection; all débris should be washed away and the cavity filled with sterilized iodoform emulsion; careful suture of any divided ligaments is important. A small drain for twenty-four hours is advisable if there has been much oozing. Recurrence must be met by a repetition of the operation, or an endeavour should be made to excise the diseased tissues in their entirety. The tendons themselves seldom require much interference.

Syphilis attacks the tendons and their sheaths in two forms. It is one of the causes of serous teno-synovitis, giving rise to a painless, very indolent, but persistent swelling, which may be symmetrical, and not infrequently leads to adhesions. The other type is a later manifestation. It attacks particularly the large and strong tendons, and may appear as a localized gumma or as an infiltrating peritendinitis. It is liable to break down, leaving an ulcer with serpiginous edges and indurated base.

The serous type has been met with about the wrist and ankle, and sometimes attacking the hamstrings. The diagnosis from tuberculosis is difficult in the absence of other specific evidence. Treatment is that for the disease.

A **simple ganglion** is a cystic swelling developed in connexion with a tendon sheath, especially in the vicinity of a joint. Some authorities regard ganglia as pouch-like protrusions of the synovial lining of the sheath through the fibrous envelope. When occurring as a sequel of teno-synovitis it is possible that this is their mode of origin. Others look upon them as the result of colloid degeneration of hyperplastic peritendinous tissue. If the peripheral parts of a ganglion, removed intact, be examined, it will often be found histologically indistinguishable from a lymphangioma; there are numerous hæmic capillaries amongst the lymphatics in some cases, but the spaces seem to be derived from dilated lymphatics, and suggest that the main cyst has the same origin.

The cysts are commonest on the back of the hand (Fig. 785), but they are not infrequent on the tendons about the ankle, and occasionally are seen in other situations, such as the inner side of the head of the tibia. At times appearing subsequently to inflammation of the sheaths, or following excessive use, as by typists and pianists, at others they are met with in childhood, and in the absence of any recognizable cause. They are commoner in women than in men. They are found as globose swellings in the course of tendons, or near their insertion. Sometimes there is free fluctuation, but more often they are so tense as to feel solid and even as hard as bone. Movements of the tendon affect their position but little, but tension on the tendon fixes them completely. A ganglion is seldom painful, but aching and weakness of the part are often sufficient to incapacitate for special work. Moreover, the swelling is conspicuous and unsightly.


Fig. 785.—Ganglion in connexion with tendon of right flexor carpi radialis. (*Westminster Hospital Museum, No* 385c)

The best **treatment** is excision under local anæsthesia; it is necessary to infiltrate the tendon sheath as well as the subcutaneous tissues. Often the cyst can be removed intact without difficulty, but careful dissection may be necessary when it is close to joints, with the capsule of which it often has intimate connexion. If excision be refused, or the cicatrix be an objection, probably the best way is to make a wide incision in the wall of the cyst by a fine tenotomy knife introduced through a skin puncture. The contents, a glairy fluid like white of egg, but tinged with pink or brown or yellow, should be expressed, and a bandage firmly applied for twenty-four hours. This method, simple forcible rupture, and the injection of iodine or carbolic acid are all liable to be followed by recurrence.

APONEUROSES

It is exceptional for any inflammatory lesion to be limited to fasciæ or aponeuroses. These share with the muscles in the production of lumbago and similar painful conditions. When gonorrhœal, influenzal, rheumatic, or other infections single out fasciæ and ligaments for attack, the diminution in tensile strength of the fibrous tissue caused by the bundles being dissociated by, and bathed in, fluid rich in toxins leads to rapid formation of deformities, such as flat-foot. On the other hand, the organization of inflammatory products often leads to contractures in which the fascial structures play either a principal or a secondary rôle.

Gouty deposits in the fasciæ cause both very chronic and very abrupt passing phenomena. The urates may be minutely interstitial in distribution, or aggregated in masses which may even determine necrosis of the overlying skin. The gouty are perhaps more liable than others to the palmar deformity known as Dupuytren's contracture, and described elsewhere (p. 1118).

Fibroma, chondroma, and osteoma of fasciæ are described, but sarcoma is probably the most common neoplasm.

TUMOURS OF MUSCLES

Angiomas are generally found in young people, and the capillary telangiectatic type, at any rate, is probably congenital. Most of the tumours have been true cavernous angiomas. (Plate 131.) They are more common in the muscles of the lower extremity than of the upper, are generally single and limited to one muscle, but may be multiple and may be diffuse. A few cases have been associated with cutaneous angiomas. Of 65 examples, only 11 were diagnosed before operation, but if the characteristic signs are present they may be easily recognized. Pulsation, thrills, and murmurs may be observed; the tumour is compressible, unless thrombosis has occurred, when the surface may be nodular. Contraction of the muscle hardens the mass and diminishes lateral mobility; elastic constriction, or elevation of the limb, may alter the size of the growth. The tumours are not tender, but are painful, especially if growing rapidly, and often give rise to impaired usefulness of the limb. Complete removal, even if it necessitate excision of an entire muscle, is required to ensure freedom from recurrence, but a few cases have been cured by partial operations.

Lymphangioma has been already described (p. 172).

Lipoma.—Intramuscular lipomas are curiosities. They occur in the biceps brachii, the sural muscles, and the tongue. They are soft, "fluctuating" tumours, which increase in density when the muscle is tense, and, indeed, may be palpable only during contraction. It is increase in size that generally attracts attention, for they are neither painful nor tender, but may cause some weakness of the muscle. They may be mistaken for cysts. Enucleation is extremely simple.

In some instances fatty tissue accompanies the angiomatous.

Subfascial and intermuscular lipomas are considered in another article (Vol. I., p. 392).



Angioma of the gracilis muscle (removed by C. Stonham).
(Westminster Hospital Museum No 383)

PLATE 131.

Fibromas are rare. The "desmoid" tumours of the abdominal musculature are probably in most instances the result of rupture, hæmorrhage, or myositis. Some desmoids are mildly fibro-sarcomatous, with some tendency to recur locally, but do not cause widespread metastasis.

[illegible]

fibrous character, others very cellular. Round, spindle, and giant cells occur Hæmorrhages are common.

The tumour is at first indolent, but when growth is rapid, or wide local extension has taken place, becomes painful. The cutaneous veins over the mass are frequently dilated. The lymphatic glands are seldom involved.

Operation should follow instantly upon diagnosis, and must be very free; at least the whole muscle must be excised. Recurrence is frequent, and amputation should not be delayed.

The **rhabdo-myomas** which occur in the bladder in young children are perhaps derived from the striped muscle of the sphincter. **Leio-myomas** of the abdominal wall have been met with in females, and are said to be derived from the round ligament.

C [illegible] econdarily, by direct extension or met[illegible] not recognizable the diagnosis is diffi[illegible]

Cysts.—For echinococcus cysts, *see* Vol. I., p. 632. Dermoids or teratomas have been found in the muscles of the cheek and neck Cysts resulting from old effusions of blood, and others possibly derived from angiomatous tissue, are occasionally met with.

TUMOURS OF TENDONS AND TENDON SHEATHS

Isolated examples of **chondromas, myxo-chondromas,** and **fibromas** are to be found in museums. **Lipomas** of tendon sheaths give rise to confusion in diagnosis; they occur in the palm of the hand, and are mistaken for chronic teno-synovitis; on the finger such a lipoma may be mistaken for a ganglion. Certain forms of angioma are properly described as "peritendinous," and are closely related to the vessels of tendon sheaths.

Myelomas of tendons and their sheaths present close resemblances to those of endosteal origin, but possibly are distinguishable by the scantiness of giant cells. Their usual site is the palmar aspect of the hand.

Sarcomas of tendons and fasciæ may be of the round or spindle-celled type, and often are so vascular as to be designated "angio-sarcomas." They are lobulated masses, soft or hard, not involving the skin until late, but disseminating early, and recurring even after early operation.

For full bibliographies *see*—

Brouardel et Gilbert, *Nouveau Traité de Médecine et de Therapeutique,* fasc xxxviii, par Marinesco.

Le Dentu et Delbet, *Nouveau Traité de Chirurgie,* fasc. ix, par Louis Ombrédanne.

BURSÆ

BY E. D. TELFORD, M.A., B.CH., F.R.C.S.

General considerations.—Bursæ are sacs enclosing a small amount of serous or synovial fluid, and serving the purely mechanical function of diminishing friction and facilitating gliding movements.



Fig. 786.—Adventitious bursa from hinder surface of upper arm. (*Natural size.*)
(*Manchester University Museum.*)

Their number is large and their distribution wide, but both are subject to considerable variations. The superficial bursæ show a special tendency to inconstancy in position and indefiniteness of structure. The deeper ones are, on the whole, more constant, and present a well-defined capsule with a definite lining membrane; certain of them may communicate with the neighbouring joint, and are therefore additionally important in that they share in and may be the initial focus of articular disease.

Being designed to obviate the ill effects of pressure, bursæ naturally tend to develop at points of repeated pressure incidental to the patient's work or habits. Bursæ so formed are termed adventitious, and are often described as "occupation" or "trade" bursæ. (Fig. 786.) The condition is well illustrated in chronic enlargement of the prepatellar bursa ("housemaid's knee"), of the olecranon bursa ("miner's elbow"), and of the bursa over the tuber ischii ("weaver's bottom"). Similar adventitious bursæ may form over bony prominences of pathological origin, such as the projection of the spinous processes in Pott's disease, or over the displaced head of the astragalus in some forms of talipes, or in relation to the ends of amputation stumps. Since bursæ owe their origin and growth

to mechanical causes, it must follow that the bursal system tends to increase in number and complexity with increasing years.

A fully formed bursa presents a definite capsule consisting of fibrous tissue lined by a delicate endothelial membrane. The contained fluid, usually small in amount, is serous in character. The adventitious bursæ are often more primitive, and sometimes are little more than enlarged and loculated spaces in the subcutaneous connective tissue.

Structurally, bursæ are part of the lymphatic system, and this relationship finds frequent illustration in practice. The acute inflammatory conditions of bursæ are liable to spread apace and to produce marked constitutional effects, whilst, conversely, an acute inflammatory lesion may light up a similar process in a bursa situated on the proximal side of the inflamed area. This latter case is well illustrated by the frequency with which a septic focus, such as a furuncle of the leg or forearm, will become the cause of acute mischief in the prepatellar or olecranon bursa.



Fig. 787.—Olecranon bursal hæmatoma of seven weeks' duration in a bricklayer.

The evident structural and functional resemblance of bursæ to tendon-sheaths and joints is borne out by the close analogy of the various diseases of these structures.

INJURIES OF BURSÆ

The exposed position of many bursæ predisposes to injury in the form either of contusions or of open wounds.

Contusions of Bursæ

Contused wounds of bursæ are of common occurrence, especially over the front of the knee and the point of the elbow. The injured bursa is apt to become tensely distended with blood, and to form a bursal *hæmatoma*. (Figs. 787, 788.) This accident may happen from comparatively trivial causes in bursæ which are already chronically

In suppurative cases the bursal tumour is soon masked by swelling of the surrounding tissues. The local signs of heat, redness, and tenderness are much more marked, whilst the mottled, brawny, and œdematous skin gives positive evidence of the presence of pus. There is early and rapid absorption from the inflamed sac with marked and, in some cases, severe intoxication.

Diagnosis.—The existence of a tense, inflamed, fluctuant swelling at the site of a bursa renders the diagnosis of acute bursitis easy. Extension of the swelling to surrounding structures, and consequent loss of outline, together with mottling and œdema of the skin, show the presence of pus. In acute bursitis occurring in the neighbourhood of a joint some superficial resemblance to acute arthritis may be induced. It should be noted, however, that the swelling in acute bursitis does not reproduce the anatomical outlines of the distended synovial membrane of a joint. It is true that some synovial effusion in the joint may be caused by the adjacent acute process in the bursa, but in such cases the local pain and the constitutional results are not nearly so severe as in acute suppurative arthritis.

Treatment.—In the early stages of the disease, rest combined with the local application of an evaporating lotion will afford relief. Appropriate treatment should be prescribed for any exciting constitutional condition. As soon as it is evident that pus is forming, free incision and drainage should be provided. If doubt exist as to the presence of pus, exploration with a hollow needle is preferable to waiting for the further development of symptoms. In acute bursitis of either form the immobilization of the part is essential. If the infection be a purely pneumococcal one, treatment by evacuation and closure is usually successful.

Chronic Bursitis (Chronic Enlargement of Bursæ)

The **causes** of chronic inflammation of bursæ are three—injury, syphilis, and tuberculosis. Of these causes injury is by far the most important. Tuberculous and syphilitic diseases of bursæ are less frequent, and possess certain features which distinguish them from cases of traumatic origin. They are separately described later (pp. 721, 722).

In chronic bursitis of traumatic origin the injury itself may be trivial. The constant repetition rather than the severity of the injury determines the lesion, and in consequence this disease is found most often in "occupation" and adventitious bursæ. Probably trauma is not always of itself a sufficient explanation, since of many engaged in any particular occupation but few will exhibit chronic bursal enlargement.

The condition is usually progressive, and leads eventually to

profound alteration in the affected bursa. The course may be chronic throughout, but acute or subacute exacerbations are not infrequent.

Pathology. T



Fig. 789.—Loose bodies from enlarged adventitious bursa of thigh. (*Half natural size.*)

(*Manchester University Museum.*)

terior of the sac may show numerous pedunculated outgrowths which occasionally become detached and form loose bodies. (Fig. 789.) The numerous "melon-seed" bodies sometimes encountered probably suggest a chronic tuberculous rather than a traumatic origin. In old-standing cases the wall of the sac may be stiffened by deposits of calcareous material. The bursa contains a *quantity of thin* clear or

slightly turbid fluid, variable in amount from time to time, but always present in much greater quantity than the normal. The chronically enlarged bursa, like other pathological conditions, shows an abnormal susceptibility to acute inflammatory disease.

Physical signs.—The site of the bursa is occupied by a well-defined cystic swelling. This swelling at first tends to reproduce the normal outline of the bursa, but as the tumour increases it may become irregular or lobulated in shape, and in advanced cases may be actually pedunculated. (Figs. 790, 791, 792, 793.) Fluctuation is, as a rule, easily obtained, except in those cases in which the increase is in the

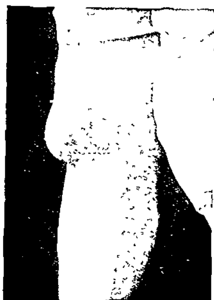


Fig. 790.—Chronically enlarged prepatellar bursa of two years' duration in a domestic servant.



Fig. 791.—Bursa removed from case shown in Fig. 790, laid open. (*Half natural size.*)

wall rather than in the fluid contents. Translucency may be elicited in the larger and more thin-walled superficial tumours. The skin over the swelling commonly shows thickening and corrugation from pressure. Where vegetations or loose bodies are present a delicate crepitus may be felt on handling the tumour.

Symptoms.—Beyond the discomfort and hindrance of the tumour the enlargements of the superficial bursæ cause no marked symptoms; deeply placed swellings give rise to a sense of weakness or of aching on exertion. Severe pain may be caused by pressure of the tumour on important nerve trunks, such as the pain occasioned by the pressure of an enlarged psoas bursa on the anterior crural nerve.

Treatment.—Progress of the condition may be checked by

rest, change of occupation, or the provision of some protection against pressure. In the slighter and more recent cases, rest combined with counter-irritation, as by a blister, is often successful in reducing the swelling. For the larger and older cases the extirpation of the sac is the only possible treatment. Aspiration and injection are futile and may be dangerous.

The sac is to be removed with the most scrupulous cleanliness through a flap-like incision planned to avoid subsequent pressure. Where a communication with a joint is encountered, there is usually a definite pedicle requiring ligature or suture. If the operator is obliged to leave behind any portion of the wall, the part left should be scraped and touched with pure carbolic acid to destroy its endothelial lining.



Fig. 792.—Large loculated prepatellar bursa of four years' duration in a charwoman.

Tuberculous Disease of Bursæ

Tuberculous disease of bursæ is not common. It is seen chiefly in bursæ near the articular ends of the long bones, and is so frequently associated with disease of the underlying bone as to suggest direct extension from the bone.

Pathology.—The bursal wall is gradually thickened by the deposit of tubercles and fibrous tissue. The bursa enlarges steadily and contains thick tuberculous pus with caseous débris The cavity may contain "melon-seed" bodies which have the same appearance and origin as those found in tuberculous teno-synovitis. The bursa eventually becomes adherent to the skin, and after a period of increasing tenuity and lividity of the skin the surface gives way and a typical tuberculous sinus results. The thickened infiltrated wall of the sac is likely to maintain the sinus indefinitely, but a spontaneous cure is attained in some cases.

Diagnosis.—The tuberculous nature of a bursal swelling may be suspected if the bursa is moderately enlarged, has fairly stout walls, and yields evidence of loose bodies in its interior. History of

injury may be absent, and the enlargement is usually more rapid than in chronic bursitis of traumatic origin. The patient should be thoroughly examined for corroborative evidence of tuberculosis.

Treatment.—If possible the diseased bursa, with any attached sinuses, should be excised in one piece. In other cases free opening, scraping, and regular dressing are all that is feasible. Rest and constitutional treatment are, of course, essential.



Fig. 793.—Large loculated bursa removed from the case shown in Fig. 792. (*Two-thirds natural size.*)

Syphilitic Disease of Bursæ

In secondary syphilis a subacute bursitis may occur, and in the tertiary stage a bursa may be the site of gummatous deposits.

Pathology.—In gummatous disease the bursal wall is thickened, often to a great extent. The gummatous deposit breaks down in one or more places, and eventually points through the skin, leaving a characteristic ulceration which is sometimes multiple. Under appropriate treatment, however, the process is usually arrested before pointing occurs, but the organization of the gummatous tissue commonly leaves some permanent enlargement and induration of the wall of the sac.

Diagnosis.—Syphilis is indicated where a bursa enlarges somewhat rapidly, with much thickening of its wall and signs of subacute bursitis. If the condition has gone on to ulceration the sharply cut ulcers with their "wash-leather" sloughs are pathognomonic. The disease is most common in the prepatellar bursa, and other signs of syphilitic infection will usually be found.

Treatment.—In the pre-ulcerative stage the treatment advised

for non-suppurative bursitis together with the internal administration of potassium iodide will usually effect a rapid cure. If ulcers are present, local treatment by mercurial ointment or lotion is desirable. In old-standing cases the ulcers may prove very tedious, and this is especially likely if syphilitic disease of the underlying bone is present.

NEW GROWTHS OF BURSÆ

New growths of any kind in bursæ are exceedingly rare, and but few instances have been recorded. The reported cases include examples of endothelioma, fibroma, myxoma, and sarcoma. Their characters and treatment do not differ from those of similar growths occurring in other regions of the body.

AFFECTIONS OF SPECIAL BURSÆ

Thyroid and infrahyoid bursæ.—Chronic enlargement of these bursæ gives rise to a superficial rounded and thin-walled cyst in the middle line of the neck.

Tuberculous disease is sometimes seen; the resultant sinus may be long, and forms one variety of median cervical fistula.

Bursæ [illegible]
region are (1) [illegible]
infraspinatus, [illegible]
(5) an occasional adventitious bursa over the acromion.

Subdeltoid bursa.—This, the largest of the shoulder bursæ, is inter- [illegible]
the deltoid with bulging at the anterior and posterior borders of the muscle. Abduction [illegible]
cases be at [illegible]
bursa may [illegible]

Of the remaining bursæ, those of the **subscapularis** and **infraspinatus** commonly communicate with the joint, whilst the sheath of the long tendon of the **biceps** is always a prolongation of the synovial membrane. These bursæ are therefore likely to be involved in disease of the joint, and distension of these sacs may be regarded as evidence of disease within the articulation.

Bursæ about the elbow.—The more important bursæ of this [illegible]

[illegible] expansion of the triceps tendon; hence the not uncommon association with disease in the olecranon itself. The bursa occupies a position such exposed to injury; both contusions and open wounds are of common

occurrence. Septic foci on the hinder surface of the forearm not infrequently lead to acute inflammation of the bursa. Suppuration is apt to be very acute; the thin-walled sac soon gives way, and a diffuse cellulitis with severe local signs and considerable systemic invasion is set up.

Chronic enlargement is common in those occupations which involve pressure upon the point of the elbow; it may be seen also in patients, long bedridden, who are in the habit of using their elbows to raise themselves from the bed.



Fig. 794.—Incision for removal of enlarged olecranon bursa.

Excision, if adopted, should be done through a curved incision with the convexity directed towards the upper arm (Fig. 794); the resulting cicatrix is then removed from the risk of subsequent pressure.

2. **Bicipital bursa.**—A small bursa lies between the biceps tendon and the smooth anterior portion of the bicipital tuberosity of the radius, and a second bursa may be found between the tendon and the ulna. Enlargement of either of these bursæ will lead to a deeply seated cystic swelling on the front of the forearm immediately below the bend of the elbow. Movements of flexion and supination will be limited and painful.

Bursæ in the region of the hip.—The chief are —(1) ischial, (2) ilio-psoas, (3) trochanteric.

1. **Ischial bursa.**—This is an ill-defined and variable sac which is sometimes enlarged from pressure—"weaver's (or lighterman's) bottom." The increase in size may be considerable, and the tumour almost solid. The removal of the enlarged bursa is likely to involve a tedious dissection, as the bursa is rarely well defined, and may extend deeply beneath the gluteus maximus.

2. **Ilio-psoas bursa.**—A large bursa lies between the ilio-psoas tendon and the capsule of the hip-joint, sometimes freely communicating with the joint; it forms a tense cystic swelling on the front of the thigh, in the region of Scarpa's triangle. Chronic enlargement occurs but rarely.

The products of both acute septic and tuberculous disease of the hip-joint may invade the bursa and thence may reach the psoas sheath, producing a typical psoas abscess; in this way a tuberculous psoas abscess may arise from hip disease in the entire absence of any spinal lesion.

3. Trochanteric bursæ.—In this region are found several bursæ. There is one, often large and loculated, between the tendon of the gluteus maximus and the trochanter; a second is found between this tendon and the vastus externus. A bursa is interposed between the tendon of the gluteus medius and the bone, whilst another lies between the tendon of the gluteus minimus and its insertion. Finally, a subcutaneous bursa may occur over the trochanteric eminence.

Disease of these bursæ, usually tuberculous, and seated in the bursa beneath the gluteus maximus, is fairly common. There is often tuberculous disease of the trochanter, and it is probable that osseous disease, of epiphysial origin, is the primary lesion. Tuberculous disease of the trochanteric bursæ may be mistaken for tuberculous arthritis of the hip. It should, however, be noted that the characteristic deformity of morbus coxæ is absent, and that limitation of hip movements is much less than in disease of the joint. The presence of the rotation at the hip-joint is especially important in arriving at a diagnosis of bursal as opposed to joint disease.

The enlarged tuberculous bursa should be excised before the skin has become thin or perforated. If sinuses are present they may be enclosed in an oval incision, and the remains of the bursa extirpated in one piece with them. In either case the underlying bone should be examined, and any carious patch thoroughly treated with gouge or spoon.

Bursæ about the knee. [illegible]

and semitendinosus muscles.

1. Patellar bursæ. [illegible]
lower portion of the [illegible]
is frequently the seat [illegible]
condition may result [illegible]
the front of the leg or foot. The inflamed bursa forms a large fluctuant swelling on the front of the knee, superficial to the patella. If it is unreliev[illegible]
to [illegible]
of [illegible]
in [illegible]
neurosis, and consequently osseous disease secondary to bursal disease is uncommon.

The abscess resulting from acute suppurative bursitis should be incised by free lateral incisions, which combine the advantages of good drainage with scars that are out of the way of subsequent pressure. (Fig. 795.)

[illegible]
(" h[illegible]
tain[illegible]
rem[illegible]
the [illegible]
nee[illegible]
of the deeper portions of the bursa with the capsule of the knee call for great care to avoid damage to the joint.

(*b*) A small bursa between the skin and the tibial tuberosity may occasionally be enlarged. Its lesions present no special features.

(*c*) A small bursa situated between the ligamentum patellæ and the head of the tibia is sometimes enlarged as the result of sprain. Considerable pain results, and a well-defined cystic swelling bulges on each side of the

ligament. If the swelling increases still further it is liable to extend in an upward direction, and by its pressure on the synovial membrane of the knee-joint may give rise to one variety of "internal derangement."

2. *Popliteal bursæ.*—Of these bursæ, two are in relation to the inner hamstrings and four are placed on the outer side of the popliteal space.

The two on the inner side are—(*a*) a large bursa situated between the inner condyle of the femur and the inner head of the gastrocnemius and the semimembranosus, between which muscles it sends a prolongation: this bursa often communicates with the joint; (*b*) a small bursa found between the tendon of the semimembranosus and the internal tuberosity of the tibia. The four on the outer side are—(*a*) one between the popliteus tendon and the

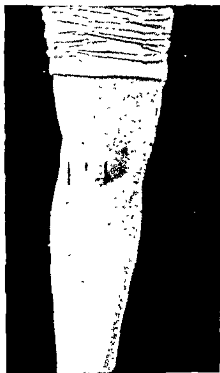


Fig. 795.—Incisions for drainage in acute suppurative bursitis (prepatellar bursa).

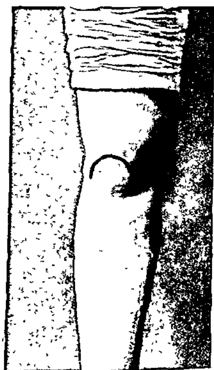


Fig. 796.—Incision for removal of a prepatellar bursa.

external lateral ligament of the knee; (*b*) another between the popliteus tendon and the head of the tibia: this is always a diverticulum of the knee-joint; (*c*) a third interposed between the biceps tendon and the external lateral ligament of the knee; (*d*) commonly a fourth between the external condyle and the outer head of the gastrocnemius.

Any of these popliteal bursæ is liable to chronic enlargement, and the condition occurs in those whose occupations demand prolonged standing and exertion. Over-exercise or sudden strain appears to determine the enlargement in some cases. The bursa most commonly affected is that in relation to the gastrocnemius and semimembranosus. This bursa, when enlarged, forms a firm, elastic, often ovoid swelling. The tumour sometimes

has a transmitted pulsation and loses its sharpness, or may be partially reducible on flexion of the knee. Fluctuation can be readily obtained if the knee is slightly flexed. In recent cases rest to the knee may secure the disappearance of the swelling, but in the older cases the extirpation of the sac is the only satisfactory treatment. The operation presents no special difficulties, but should not on any account be undertaken unless the operator can rely on his "asepsis," since free communication with the joint will be *encountered in many cases.*

3. Sartorius, gracilis, and semitendinosus bursæ.—There is usually a bursa between the tendon of each of these muscles and the internal tuberosity of the tibia. Others may occur between the tendons themselves. When enlarged, these bursæ form very definite cystic swellings over the inner side of the head of the tibia, presenting the same features and calling for the same treatment as those of the popliteal group. Communication with the joint is unlikely. These bursæ are said to be among those most commonly affected in tertiary syphilis.

Tendo-Achillis bursa.—A small bursa lies between the insertion of this tendon and the os calcis. It is important because of its frequent enlargement from over-exertion or from the pressure of ill-fitting boots. The sac, when enlarged, [illegible]
either side of the tendo [illegible]
of the ankle-joint results, [illegible]
this bursal enlargement is [illegible]
that there is no evidence of distension on the anterior aspect of the joint. The enlargement usually gives distinct "silken" crepitus in movements of the ankle; the condition is associated with some pain, which is usually sufficiently severe to prevent walking.

In recent cases rest is all that is needed, but should the enlargement become chronic, as it may after repeated strains, excision will be required.

DISEASES OF BONES

By C. C. CHOYCE, C.M.G., C.B.E., B.Sc., M.D., F.R.C.S.

INTRODUCTORY

The bony skeleton serves the functions of supplying a rigid support for the soft tissues, of protecting important and easily damaged tissues, such as bone-marrow, brain, etc., of affording attachments for muscles and tendons and giving them a mechanical purchase.

Osseous tissue is of two varieties, *viz.* the compact and the cancellous. *Compact* bone is firm and is composed of lamellæ arranged (*a*) along the periphery, (*b*) in concentric Haversian systems surrounding the Haversian canals, and (*c*) in the gaps between these systems (intermediate lamellæ). *Cancellous* bone, of much looser texture, consists of straight or arched trabeculæ definitely arranged to meet pressures and strains. Although this architecture is apparently so fixed, *bone is essentially plastic and retains throughout life the capacity* of gradually altering the inter-relation of its trabeculæ and systems to meet new circumstances of stress and strain, such as those that result from alteration of axis following malunion of a fracture; in such a case there is an alteration in the balance between osteoblastic and osteoclastic activities and in the direction and strength of the trabeculæ. In many diseases, such as acromegaly and osteitis deformans, this definite architectural correlation of pressure and strain lamellæ is lost and the bone is laid down in an irregular and less obviously purposive manner.

In lacunæ in the calcareous material are found the branching bone-cells, while through the Haversian canals and medulla run blood-vessels. The medullary spaces contain a fatty vascular marrow which serves to nourish the bone and plays an important rôle in the development and regeneration of blood cells.

Bones are divided into—(*a*) short bones, such as the carpals, which consist of a thin, compact layer surrounding a loose cancellous core, the meshes of which contain connective tissue and marrow; (*b*) flat bones, such as those of the cranial vault, consisting of two flat plates of compact bone enclosing a middle cancellous

layer (diploë); (c) long bones developing from a shaft centre, or diaphysis, and one or more terminal epiphyses. The shaft consists of a compact tube, thickest near the middle of its length; within this is the medullary cavity, plugged at either end by masses of cancellous tissue. The epiphyses are formed of cancellous bone surrounded by a thin, compact layer.

During growth the epiphysis is separated from the diaphysis by the actively developing epiphysial plate of cartilage.

The *medulla* fills the medullary cavity and the cancellous interstices and sends prolongations through the Haversian canals.

The *periosteum* is a vascular fibrous membrane surrounding the bone except where this abuts on a joint cavity. It is loosely attached to the shaft and more firmly at the epiphysial ends.

The *vascular supply* is derived from the nutrient artery from the periosteum through its ramifications in the medulla, and from vessels that pass in through simple Volkmann's canals to the Haversian systems, especially near the epiphysial ends; in this way there is an anastomosis between the two sources Large veins are found in the medulla both of the medullary canal and of the cancellous tissue, and in acute infective conditions may be the seat of thrombosis and the origin of pyæmic emboli. The area of the venous channels in this neighbourhood is considerably greater than that of the arteries; the marked slowing of current that results may predispose to the lodgement of microbes travelling in the blood-stream.

Bone is *developed* either (a) in membrane, e.g in the calvarium, by the deposition of calcified spicules and osteoblasts in a cellulo-fibrillar matrix; or (b) in preformed cartilage by calcification of the cartilage matrix and cell capsules, rearrangement of the cells, formation of medullary spaces, followed by ingrowth of embryonic osteogenetic connective tissue from the deeper periosteal layers and of osteoblastic cells from the medulla

The osseous development is regularized by the balanced action of the formative osteoblasts and of other cells, osteoclasts, which absorb the cartilage matrix, remove excess of osseous tissue, and mould the bone.

Growth of bone.—Like other tissues, bone grows by enlargement in three dimensions. This is accomplished by destruction of already formed bone by osteoclast cells, and the concurrent production, by osteoblasts, of bone in a larger mould; a balanced activity of these two groups of cells is obviously necessary—for example, near the swelling ends of a diaphysis where a continuous process of remodelling must be going on during the period of growth. But the total growth necessary for the change from the infant to the adult bone is greater in the axial than in the transverse direction; therefore a

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form of growth is elaborated for relatively rapid *increase in length.* A growing long bone consists typically of a diaphysis and two *epiphyses,* the latter constituting the expanded ends that carry the joint surfaces, and ossifying separately from the diaphysis; when growth of the bone is well advanced, these three elements unite. Separating the ossific centre of an epiphysis from that of a diaphysis is a plate of cartilage, the epiphysial "line," which actively grows towards the diaphysis and, more slowly, towards the epiphysis. The conversion of cartilage into bone histologically shows three stages, viz. (*a*) multi-

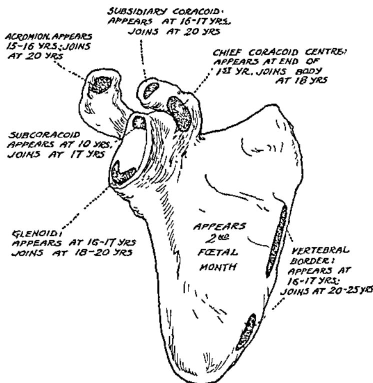


Fig. 797.—Ossification of scapula.

plication of the cartilage cells in a longitudinal direction so that regular columns of cells, separated by an avascular matrix, become arranged parallel to the long axis of the bone; (*b*) enlargement of the individual cells and calcification of the cartilage matrix; and (*c*) entry of osteoclasts, blood-vessels, and osteoblasts from the edge of the already formed bone, resulting in partial destruction of the calcified cartilage and in the simultaneous production of new bone.

In a healthy bone these three stages are seen as transverse zones; the zone representing the third stage, that of destruction and bone-formation, is mechanically the weakest part of the growing bone; it is here, therefore, on the diaphysial side of the epiphysial cartilage

especially, that potential mobility is greater, that rotary strains are most apt to inflict damage, and that organisms travelling in the blood-stream are most likely to settle down and to cause infection of the growing bone. With a view to the prevention of rotary twists in some of the larger bones, for instance at the lower epiphysis of the femur, the lower aspect of the diaphysis is raised into four bosses, which are somewhat imperfectly fitted into four corresponding concavities in the upper aspect of the epiphysis. The dates of appearance and of consolidation of the various important centres of bone are there-

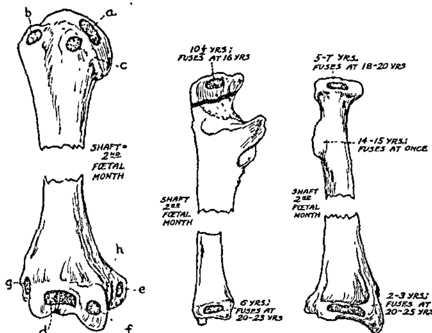


Fig. 798.—Ossification of humerus, ulna, and radius.

fore of surgical importance; those of the limbs, of the scapula, and of the innominate bone are shown in the accompanying diagrams (Figs. 797–802).

Growth in length chiefly occurs at the metaphysis, i.e. the diaphysial side of the epiphysial cartilage; in the upper limb it is most active at the shoulder and wrist, in the lower at the knee. These epiphyses, although appearing earlier, join the diaphysis later than those at the other ends. The general rule may be stated for the long bones of the limbs, that the epiphysis towards which the

for many months, *e.g. in the treatment of tuberculous hip-disease.* The nervous changes associated with infantile palsy, anæsthetic leprosy, syringomyelia and, sometimes, tabes dorsalis are factors in the production of atrophy. Long-continued constant pressure, such as that exerted by aneurysms or by tumours, causes similar changes. Diminution of blood supply[1] is not in itself a cause in disuse-atrophy; in fact, such bone atrophy is an active process requiring blood circulation for its progress. *On X-ray examination an atrophic bone looks*

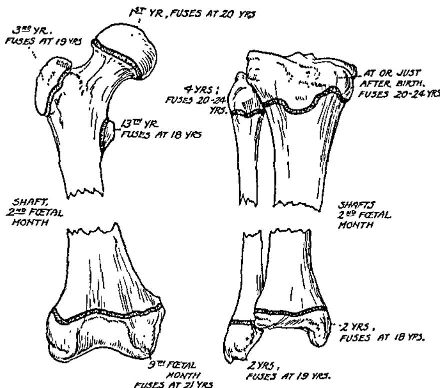


Fig. 801.—Ossification of femur, fibula, and tibia.

thin, and at first shows too clearly the delicate tracery of the osseous tissue; later, the trabeculæ lose definition, and some disappear completely. *In some cases, e.g. in infantile paralysis, not only does the* bone of the affected part of the limb show atrophy, but also change of shape in that the shaft may diminish in breadth to a greater extent than the articular ends. The breaking strength diminishes in exact ratio with the reduction in quantity of bone.

(*b*) **Excessive and ill-regulated growth** is seen in *gigantism,* which may be general or local, in acromegaly, etc. Probably the growth of bone and the balance between osteoblastic and osteoclastic proces es is governed by an internal secretion. Disturbance

[1] Allison and Brooks.

of the pituitary body is associated with acromegaly, and it has been suggested by Keith that it is also the important factor in the irregular lamellar growth seen in gigantism and in osteitis deformans.

Localized overgrowth is sometimes met with as the result of

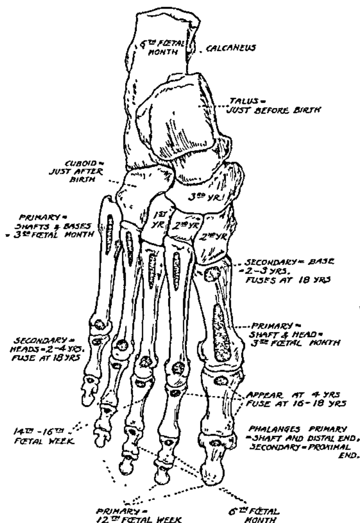


Fig. 802.—Ossification of bones of foot and tarsus.

Order of appearance of the primary phalangeal centres.—*Ungual phalanges* 12th fœtal week. *Phalanges of 1st row* 14th to 16th fœtal week *Phalanges of middle row*: 2nd and 3rd toes, 6th fœtal month, 4th toe, just before birth, 5th toe, just after birth

chronic passive hyperæmia, e.g. in the clubbed fingers of chronic cardiac and pulmonary disease.

True hypertrophy may be seen, especially near muscular attachments, as a result of increase of strains and muscular power.

INFLAMMATION OF BONE

A bone must be looked upon as a whole: it is inconsistent with the pathological changes to consider acute inflammations of the constituent parts separately. Thus, acute periostitis rarely, if ever, occurs without more or less accompanying osteo-myelitis; and para-epiphysitis is most commonly the precursor of the combined acute inflammation of periosteum, bone, and medulla that we know as acute *osteo-myelitis*. *Chronic* inflammation is more likely to be local, though this too may affect all the constituent parts.

The processes of inflammation are modified, and the effects determined, by (*a*) the rigid, inextensible nature of bone, (*b*) the arrangement of the vascular supply.

As elsewhere, acute and subacute inflammation leads to vascular engorgement, stasis, corpuscular emigration and extravasation, cellular proliferation and infiltration, and fluid effusion, but here there is no room for the inflammatory products, and their presence rapidly causes a degree of pressure fatal to the tissues.

Necrosis, or local death, is especially probable in bone inflammation, and is induced by the following factors: (1) the action of the toxins; (2) diminution of the vascular supply. The latter may be due to (*a*) compression of the vessels by pressure of the inflammatory exudates exerted inside rigid canals; (*b*) slowing of the blood-stream, frequently with thrombosis and consequent reduction of the supply of pabulum; (*c*) raising of the nutritive periosteum off the bone by the exudates; (*d*) in some cases, especially in syphilis, arterial thickening, which also causes a reduced supply of blood; and (*e*) sometimes, in the chronic stages of inflammation or in syphilis, enclosure of the affected area by a dense layer of sclerosed bone.

The necrosed area becomes separated by erosion of the margin of neighbouring living bone by granulation tissue, and so forms a sequestrum. A small sequestrum surrounded by vascular tissue, e.g. in cancellous bone, may be absorbed, but usually healing of sinuses leading into bone cannot be expected until the sequestra have been extruded or surgically removed.

Necrosis is most apt to occur in infections due to the pyogenetic organisms, but may also occur in syphilis, and is sometimes seen in cases of phosphorus, mercury, or lead poisoning, though in all these pyogenetic infection plays an important part.

In some subacute infections, instead of necrosis of definite areas of bone, the process of *osteoporosis, caries*, or *rarefaction* occurs; in this the bone is eroded by osteoclasts and by granulation tissue, which replaces the marrow of the part, and the bone corpuscles undergo fatty degeneration. Caries is especially seen in tuberculosis, but

also in the other granuloma-forming diseases, such as actinomycosis and, occasionally, syphilis.

An example of a carious process in syphilis is to be seen in the central porotic changes in the syphilitic variety of dactylitis, in which the cancellous and medullary centre of a carpal, a metacarpal, or a phalanx is replaced by a carious material not readily distinguishable from that produced by a similar tuberculous process; another example is the erosion of the para-epiphysial line, perhaps accompanied with actual separation of the epiphysis, that occurs in syphilitic para-epiphysitis.

Osteosclerosis is a response of the bone that occurs in chronic inflammatory conditions, whether simple, syphilitic, or tuberculous, often near and enclosing areas of caries or of necrosis. The bone becomes unduly dense owing to the deposition of new bone in the cancellous spaces and Haversian canals. In syphilis large areas of bone may be affected; then the diminution of the blood supply resulting from endarteritis and osteo-sclerotic encroachment on the vascular canals, especially if combined with the admission of infective organisms, may lead to extensive necrosis in the sclerosed area. In tuberculosis the sclerosis is less in amount, is placed at the margin of the focus, and is an endeavour on the part of Nature to wall-in the offending organisms.

Simultaneous stimulation and new formation in the surrounding periosteum give rise to an *involucrum*, or bony case, around a sequestrum, or to fresh spicules around an area of caries. The degree to which this latter process occurs varies with the causative organism, and is reduced to a minimum in tuberculous caries.

Acute infective inflammation and tuberculosis of bones are most apt to attack the young before the epiphyses have become firmly united to the diaphyses.

If from a recent corpse of an adolescent a long bone be taken and an effort be made to pluck an epiphysis from the shaft, it will be found that the natural line of separation is on the diaphysial side of the epiphysial cartilage (the para-epiphysial or juxta-epiphysial line or *metaphysis*). Here, therefore, in life, wrenching and twisting strains are most likely to cause damage. In some cases, e g at the lower end of the femur, rounded knobs on the ends of the diaphyses are mortised into shallow cup-like depressions on the epiphysis to guard against twists, but they are not very efficient. Their inefficiency is especially obvious at the upper end of the tibia, one of the bones most exposed to twists during play. Such a para-epiphysial strain may be one of the causes of "growing pains." If the small blood-clot caused by the strain becomes infected by organisms via the blood-stream from the tonsils or other infected focus, acute or

chronic inflammation of a character corresponding to the etiological organism results. An abscess forms and spreads in one or more of the directions indicated in the schema (Fig. 803).

In the case of the ordinary pyogenetic organisms infection tends to spread down through the cancellous tissue into the medulla and compact bone (acute osteo-myelitis) (Fig. 803, 1), and also down under the periosteum (acute periostitis) (Fig. 803, 2). As the subperiosteal space and the medulla freely communicate through the Haversian canals (Fig. 803, 3), the usual condition is one of acute periosteo-myelitis ("acute osteo-myelitis"). At the same time the neighbouring joint may possibly, though rarely, be infected by passage of the pus in the direction of the arrow marked 4, or of that marked 5, e.g. in the hip.

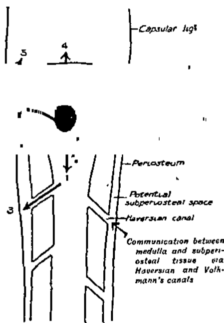


Fig. 803 —Schematic representation of a long bone, showing directions of possible spread of infection from the metaphysis (para-epiphysial or juxta-epiphysial region).

Tuberculosis may similarly arise from infection of a para-epiphysial blood-clot, but in this case there is a greater tendency to spread into the neighbouring joint, either by passage through the epiphysis or by raising the attachment of the capsule. There is a corresponding disinclination to spread down the bone, possibly because of the relative chronicity of the process and the tendency to limitation by a slight but sufficient barrier of sclerosis enclosing the focus on that side of it that is adjacent to the vascular medulla.

Acute osteo-myelitis may also, though rarely, commence as a subperiosteal infection from the blood-stream or from skin (especially in the case of a subcutaneous bone like the tibia)

In the adult, these infections, whether by pyogenetic organisms or by B. tuberculosis, may originate in the region of entry of the nutrient arteries in the tibia, ulna, or other long bones.

Acute and Subacute Periostitis

It has been taught that acute periostitis and acute osteo-myelitis may occur independently. In view of the free communication through

the Haversian canals and along the para-epiphysial line, this is very improbable, and it is safest in all cases of acute periostitis to assume the coexistence of some degree of acute osteo-myelitis, and vice versa. Localized acute subperiosteal suppuration is generally due to localized injury, usually compound. It is true, however, that very occasionally a very mild case of acute periostitis is seen in which drainage of the subperiosteal spaces suffices to cure. If this procedure be adopted the surgeon must be prepared to watch the case closely and to open the medullary cavity unless all general symptoms clear up at once.

Subacute periostitis may follow a blow. The periosteum locally becomes raised and thickened. The condition may resolve, or pus may form. In the latter case there is frequently necrosis of a superficial plaque of bone. Subperiosteal new bone is formed which may eventually disappear or may leave a "bump" on the bone. This condition may be treated by fomentations, rest with the limb in the elevated position, and Bier's congestion; if pus form, it must be evacuated. Subsequently, unless it is densely sclerosed, much of the "bump" will disappear after prolonged administration of potassium iodide, with massage and, perhaps, counter-irritants.

Chronic Periostitis

Chronic periostitis with periosteal thickening and peripheral osseous new growth may follow trauma, or the spread of infection from neighbouring ulcers or abscesses, or may result from syphilis, or sometimes from tuberculosis. A very chronic plastic "idiopathic" form may be seen in which no definite etiology can be discovered. In these cases exploratory incision and gouging of the mass is sometimes adopted with very distinct benefit to the condition; from the bone-chips Staphylococcus aureus can sometimes be grown.

In long-continued suppurative disease a toxic osteo-periostitis ossificans (e.g. "pulmonary" hypertrophic osteo-arthropathy) may show itself in the form of numerous foci of chronic subperiosteal thickenings found over the body, especially in the smaller long bones, such as those of the fingers. This condition sometimes accompanies chronic pulmonary disease; hence the name "pulmonary osteo-arthropathy," which, however, is doubly a misnomer in that it implies a constancy of pulmonary cause and suggests definite arthropathic changes apart from the bony elements of the joint; it is essentially a bony change.

Chronic periostitis may remain localized and give rise to a node of new subperiosteal bone, or it may become diffuse. The diffuse form is seen most typically in association with typhoid osteitis.

Symptoms.—Chronic periostitis shows osseous enlargements around the shaft of the bone; this thickening, when definitely established, i.e. after five or six weeks from the onset, is distinctly

revealed by X-ray examination. The shadow is definite and even, and the visible calcareous deposit, if present, tends to be laid down parallel with the surface of the bone; in this it differs from that seen in malignant disease, in which the radiographic shadow is unequal in density and shows some apparent lacunæ. Pain may be absent, or may take the form of dull aching, often worse at night, and sometimes subject to exacerbations. The symptoms of the underlying disease may also be present.

The **treatment** is that of rest combined with counter-irritation,



Fig 804.—Acute osteo-myelitis of lower end of femur.

The specimen shows great destruction in region of metaphysis, and spread thence into medullary canal and under periosteum, the joint surface is free.

(Dreadnought Hospital Museum, Greenwich)

the administration of potassium iodide, and the treatment of the causative disease. Incision into the mass sometimes relieves the pain, if this be severe enough to warrant the measure. In some cases no relief is obtained unless the shaft of the bone be opened and a long gutter gouged out.

"Pulmonary" osteo-arthropathy requires no treatment other than that of the cause.

Acute Osteo-Myelitis (Periosteo-Myelitis)

Etiology.—Acute osteo-myelitis arises in one of the ways already discussed, by infection with pyogenetic organisms, especially the Staphylococcus pyogenes aureus, though Staphylococcus albus Streptococcus pyogenes, the pneumococcus, and others may be found. The streptococcus and pneumococcus are said to be more likely than the staphylococcus to attack the neighbouring joints. The infection is generally a pure one; infections that are mixed from the first, before foreign organisms have entered by the drainage tracks and fistulæ, are more severe in type than the pure varieties.

Predisposing factors.—The important etiological factors are:

1. *Age.*—The condition may occur at any age from infancy to later life, but in the vast majority it happens before the completion of growth, mostly between the ages of 3 and 17.

2. *Sex.*—Boys are more often attacked than girls, in the proportion of 3 to 1, probably because of their greater exposure to violence

3. Some cause of general or local lowering of resistance, such as trauma, which is generally of a slight character, exhaustion, cold, or one of the exanthemata, especially scarlet fever.

4. The admission of the infective organisms either from the skin or from some distant nidus of growth, such as a furuncle, a carbuncle, an abscess, tonsillitis, etc.

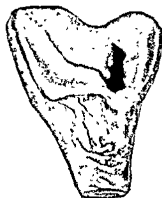


Fig. 805.—Acute epiphysitis of femur opening into knee-joint in an infant one month old.
(*St. Thomas's Hospital Museum*)

Pathology (Figs. 804, 805).—Any bone may be attacked, even the vertebræ, but the tibia and femur and upper end of the humerus are the commonest victims. As already mentioned (p. 737), the primary lesion is usually para-epiphysial, but occasionally it may begin in the epiphysis itself, or sometimes—especially in adults—at the site of an injury to the periosteum, or in the neighbourhood of the entry of the nutrient artery. The marrow is infected primarily; the disease spreads through the Haversian canals and the compact bone, also along the para-epiphysial line, and under the periosteum; the bony trabeculæ and compact cortex are secondarily disintegrated and the bone cells are killed by the action of the toxins, the pressure of the inflammatory exudates, the lifting of the periosteum, and the vascular stasis and thrombosis. Pus forms and fills the medullary cavity and subperiosteal space, forming a subperiosteal cushion of pus

which rapidly encircles the bone; it also infiltrates the lacunæ and canaliculi. Thence, much later, by bursting through the periosteum it may spread into surrounding tissues and eventually to the surface. The spread towards the joint is generally stopped by the epiphysial cartilage; in adults, therefore, there is relatively greater danger of associated acute infective arthritis than in adolescents.



Fig. 806.—Old-standing osteo-myelitis of tibia.

An involucrum encloses sequestrum of whole diaphysis, with cloacæ leading through the one to the other. The fibula shows chronic periostitis and an old united fracture

(Dreadnought Hospital Museum, Greenwich.)

The para-epiphysial inflammation may be sufficient to separate the epiphysis from the diaphysis.

The bony cortex becomes necrosed in a greater or less area. The necrosis may involve practically the whole shaft or remain quite localized. It may affect the whole thickness of the cortex, but the compact bone is generally affected to its greatest extent where it is in contact with the medullary cavity, because the medullary infection is usually more extensive than the subperiosteal.

Should the patient survive the acute poisoning, the calcareous skeleton of the necrosed area, in the course of about six weeks, gradually becomes separated from the rest of the bone and remains as a sequestrum. Synchronously the bone attempts repair by laying down round the sequestrum a subperiosteal shell of new bone, probably pierced in many places by sinuses to permit the discharge of pus from the region of the dead bone within. (Fig. 806.) This shell, at first soft, friable, and crackling, later becomes thick and dense to form the involucrum, and eventually becomes strong enough to act as the shaft. (Plate 133, Fig. 2.)

The naked-eye appearances vary with the stage. In the earliest stages the marrow merely does not bleed well; soon, however, oil-drops appear, due to destruction of fat, and also points of pus; later the marrow is entirely replaced by oily pus.

The cortex at first shows raising of the periosteum and a white, shiny surface, frequently covered with red points; when tapped

with the handle of a scalpel it rings with a sharp "dead" note as compared with that given by healthy bone. Later it looks dead-white or yellowish and lustreless. When it has been separated for some time it may be dark brown.

The involucrum is attached at either end to the healthy bone. The end of the healthy part of the medullary canal often becomes sealed by an irregular transverse plate of bone.

Sometimes, the virulence of the attacking organism and the resisting and isolating powers of the bone are so nearly balanced that the infective process, instead of causing a definite osteo-myelitis, gives rise to a large, deep abscess in the cancellous tissue near the epiphysial line—a *chronic encysted abscess* or *Brodie's abscess*, which becomes walled in by a dense ring of bone. These abscesses are commonest in both ends of the tibia, the lower end of the femur, and the shoulder end of the humerus, but may also be seen in the neck of the femur, or, indeed, towards the extremities of any long bone.

Clinical features.—A frequent clinical history is that a boy or youth, after some slight twist or trauma, feels ill and develops a sudden and very severe pain in the shaft of a long bone, usually near one epiphysial line. General malaise commonly precedes local symptoms. Occasionally, especially in severe pyæmic cases, there is at first pain in several bones near their articular ends; hence, too often, a diagnosis of acute rheumatism is made, which, if persisted in, can only lead to disaster. But the signs and symptoms early become predominant in one bone.

There is intense tenderness on local percussion; pressure on the bone at a distance at first causes no disturbance, but if continued will quite suddenly cause severe pain. The soft parts overlying the area of bone affected become swollen, and later, if the condition remain untreated, they become red and œdematous, and then pit on pressure In young children the essential physical sign is a cylindrical swelling of the limb, obliterating the normal contours, because the periosteum is raised on a cushion of pus; the bone can be felt to be enlarged near the epiphysial end, and this, with the severe degree of illness shown by the patient, will enable the diagnosis to be made. The neighbouring joint at first allows free movement without pain, but soon it is apt to show tenderness and swelling, even when it does not contain pus. General toxæmia is marked from a very early period. The temperature rapidly mounts to 101°–104° F. or higher, and the pulse-rate is increased. The face is flushed and bears an expression of pain, the tongue is furred and dry, and mild delirium is apt to supervene early. Polymorphonuclear leucocytosis usually rises quickly to 25,000 or 30,000, but in some overwhelmingly toxic cases this reaction may be comparatively fleeting; a low leucocyte count in such a case

is of bad prognosis. The soft parts around become more swollen, red, and œdematous, and unless surgically treated the patient dies of toxæmia and exhaustion, or the pus escapes externally. In neglected cases there may be an associated infective arthritis. Radiographic examination is useless except where a chronic focus has lighted up into an acute stage.

When the immediate dangers of acute osteo-myelitis have been avoided by the surgical or the natural evacuation of the pus and the relief of tension, the condition becomes chronic. The bone is enlarged by the formation of the involucrum, the surrounding soft tissues are thickened and frequently riddled with numerous large sinuses, lined with dirty granulation tissue, discharging foul and often stinking pus, and leading down through cloacæ in the involucrum to the sequestrum, which imparts a curious grating sensation and metallic clink to the examining probe.

A chronic encysted (Brodie's) abscess may remain for months or years, causing some thickening of the end of the shaft, perhaps of so slight a degree as to escape notice, but otherwise causing no trouble. More often, however, the enlargement is more obvious; there is localized tenderness of the bone, with a chronic aching or boring pain. A frequent feature is the recurrence of attacks of severe pain with accompanying localized tenderness, fever, and constitutional disturbance, usually described by the patient as "attacks of rheumatism" in the bone; I have operated upon a man of 78 who had had quarterly or six-monthly attacks for sixty years. There may or may not be a sequestrum in the abscess; usually there is none, because the condition essentially begins in the medulla. Its presence is confirmed by X-ray examination. A sinus may be present for years.

The **diagnosis** of acute osteo-myelitis is too often overlooked, and valuable time wasted in the administration of salicylates, etc. Swelling, redness, and œdema should not be awaited. They may be delayed several days

In all cases of acute pain in a bone or near a joint in youth it should be remembered that osteo-myelitis is common, while *monarticular rheumatism*, for which it is frequently mistaken, is very rare indeed at this age.

In other cases the signs may seem to indicate *disease of a neighbouring joint* rather than of the bone shaft. The joint may be swollen, extremely painful on movement, and tender; in such cases a mistaken diagnosis of *acute rheumatism* may lead to waste of time and the useless administration of salicylates. It is a sound rule to believe that all apparent cases of acute monarticular rheumatism (especially of the shoulder) in childhood and adolescence are probably really acute osteo-myelitis of the head of one of the con-

stituent bones, and to subject them to immediate surgical intervention. The diagnosis from acute rheumatism is, in some very acute cases of osteo-myelitis with marked septicæmic symptoms, rendered more difficult by the fact that in such cases there may be pain in more than one bone-end during the first day of the illness. Confusion with acute rheumatism and very acute gonorrhœal rheumatism may also occur when the osteo-myelitis attacks carpal or tarsal bones.

In *rheumatism* the pain, the constitutional symptoms, the fever, and the progressive leucocyte count are much less than in osteomyelitis, while the reaction to treatment by salicylates is rapid and the pain is largely dependent on any effort to move the joint.

Gonorrhœal rheumatism of the acute "monarticular" type may in a young adult or an adolescent be mistaken for acute osteo-myelitis. But the discovery of the primary gonococcus in the urethra or elsewhere, the fact that usually a few other joints have been affected, the relatively less acute toxæmia, and the localization of the pain and swelling over the joint and periarticular structures rather than over the bone, will generally distinguish the gonorrhœal condition.

In the acute stages of *anterior poliomyelitis* a mistake may sometimes be made, but if the cylindrical character of the swelling of the limb and the thickening of the end of the shaft of the bone in osteomyelitis be remembered, diagnosis will be facilitated.

In some very serious cases the toxæmic symptoms may be so severe as to mask the local cause; delirium and coma may come on very rapidly, the temperature may be very high, or in some profound cases may hardly be raised above the normal, and the patient rapidly dies overwhelmed by the toxins. Such cases are sometimes mistaken for *typhoid fever.*

Exacerbation of a Brodie's abscess.—The diagnosis of a localized, completely shut-off chronic abscess may be facilitated by the characteristic history of alternations of remission and of acute exacerbation of pain and tenderness, and by the demonstration, by X-rays, of a bone cavity, surrounded by a definite sclerotic encircling wall, and perhaps, but not usually, containing a sequestrum in its centre. In other cases, however, this abscess can only be distinguished from myeloid sarcoma or from localized periostitis by exploratory incision. In Brodie's abscess there is usually only one point of softening, if any at all, whereas in myeloid sarcoma several softer areas are generally present. Moreover, a skiagram shows absence of sclerosis in the latter condition.

Treatment. (*a*) **Immediate.**—In the acute stage immediate relief of tension, evacuation of the inflammatory exudates, and measures combative of the general toxæmia are urgently demanded.

The overlying soft parts and periosteum must be freely incised, the bone exposed, and the medullary cavity always widely laid open with the gouge and chisel, especially near the epiphysial line. The trephine is insufficient except as a means of rapidly exploring the marrow. The gutter made in the bone must extend up and down as far as the medulla is definitely purulent, or even necrotic and oily, until normal bleeding marrow is reached. At least one-third of the circumference of the bone should be removed, so that the marrow cavity is laid widely open without overhanging bony edges. In cases that have fallen into the surgeon's hands after the acute disease has been in progress for several days, and in which pyæmia may readily be precipitated, thoroughly sharp gouges or a circular saw must be used, and violent hammering reduced to a minimum; otherwise an infected thrombus may be detached into the general circulation and pyæmia established. The suppurating marrow should be gently removed, but vigorous curettage of the medullary cavity effectually destroys any endosteum that might otherwise survive to keep the inner aspect of the compact bone alive, and is therefore to be avoided.

The bone cavity may be thoroughly washed out with H_2O_2 or flavine (1 : 2,000), and freely drained. In children, very ill and easily terrified at the prospect of the first dressing, the trough may be lightly packed with gauze soaked with flavine, to be removed, under gas anæsthesia, at a first dressing thirty-six hours after the operation. In the rare cases of infection with B. pyocyaneus the best antiseptic is mercuric biniodide, which seems to have a special destructive influence over this organism in the tissues.

It is generally possible to avoid operative damage to the epiphysial lines; but in all cases, to avoid subsequent disappointment, it is wise to warn the parents of the possibility of defective (or occasionally excessive) growth in length at the affected line. This is especially the case in the epiphyses at the knee, shoulder, and wrist, where normally a great part of growth in length of the limbs takes place.

In those cases in which the infection has definitely spread to the epiphysis, its interior must be opened up. Accompanying effusions into neighbouring joints are usually serous, and should be left alone. If, however, they are definitely purulent, free drainage must be established. In severe cases a blood culture should be planted out, as it may give valuable evidence of a coexistent septicæmia, and as it may be used later for the preparation of a vaccine.

Occasionally, in very severe cases, the whole circumference of the bone is so damaged that immediate resection of the whole affected part, even of the whole diaphysis, may be necessary, and is justifiable in the young in such a bone as the tibia, because the fibula will help to preserve the length of the limb during reconstitution of the tibia.

This method shortens the period during which necrotic material is present in the body, and often avoids a second operation for sequestrotomy, but it is of greater immediate severity than the "gutter" method.

Finally, amputation may be demanded when, in spite of free drainage, pyæmic manifestations continue, if the wound is grey and persistently deficient in signs of reaction, or if the general health of the patient declines and signs of waxy degeneration of kidneys or intestines appear. If, as is usually the case, the amputation flaps have to be made near infected tissues, they should be packed or stitched back until clean, and then coapted by secondary suture.

(*b*) Subsequent treatment should consist in general measures directed to the elimination of toxins and the maintenance of strength, combined with the local use of prolonged daily soaking in mild antiseptic baths (H_2O_2, eusol, sanitas, weak mercuric biniodide 1 : 10,000, or warm water), and with frequent antiseptic dressings. Instillation of Dakin's solution by means of Carrel's tubes is very valuable, especially in children, who are thus relieved of the terror caused by frequent dressings.

In those fortunate cases in which adequate operative treatment has been adopted very early the bone may survive, the gutter become filled with granulation tissue, and the bony deficiency be reconstituted.

Usually, however, the shaft, or part of it, necroses, a sequestrum is formed varying from a mere shaving to the whole length and thickness of the diaphysis, and an involucrum is laid down. Unless the sequestrum be removed it will remain for years as a source of foul discharge through the cloacæ of the involucrum; this secondary operation should not be deferred until the sequestrum shall have become quite separated, for by that time a strong osseous involucrum will have developed and the granulation-lined cavity in its interior will persist indefinitely.

The surgeon should aim at removing the sequestrum when the limits of necrosis are well marked although actual separation has not yet occurred, and while the subperiosteal involucrum is still only partially and not rigidly ossified and the subperiosteal osteogenetic layer is still actively at work.

The best time for this is from about the sixth to the ninth week. Careful splinting is necessary, especially when there is no splint bone (e.g. the fibula) to maintain the natural length of the limb during regeneration.

Some surgeons recommend that where there is no accessory splint bone it is better to wait longer until the new subperiosteal bone is rigid enough to prevent deformity. They would wait about

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In those fortunate cases in which adequate operative treatment has been adopted very early the bone may survive, the gutter become filled with granulation tissue, and the bony deficiency be reconstituted.

Usually, however, the shaft, or part of it, necroses, a sequestrum is formed varying from a mere shaving to the whole length and thickness of the diaphysis, and an involucrum is laid down. Unless the sequestrum be removed it will remain for years as a source of foul discharge through the cloacæ of the involucrum; this secondary operation should not be deferred until the sequestrum shall have become quite separated, for by that time a strong osseous involucrum will have developed and the granulation-lined cavity in its interior will persist indefinitely.

The surgeon should aim at removing the sequestrum when the limits of necrosis are well marked although actual separation has not yet occurred, and while the subperiosteal involucrum is still only partially and not rigidly ossified and the subperiosteal osteogenetic layer is still actively at work.

The best time for this is from about the sixth to the ninth week. Careful splinting is necessary, especially when there is no splint bone (e g. the fibula) to maintain the natural length of the limb during regeneration.

Some surgeons recommend that where there is no accessory splint bone it is better to wait longer until the new subperiosteal bone is rigid enough to prevent deformity. They would wait about

twelve weeks, or until "the total diameter of the involucrum as judged by the X-ray is equal to one-half the diameter of the normal shaft."[1] It is better to endeavour to prevent undue deformity by carefully applied artificial splints and to operate earlier—when the subperiosteal bone is still being actively laid down—than to wait till the twelfth week and run the risk of imperfect filling of the central cavity. Following sequestrotomy in the seventh or eighth week after the primary operation, not infrequently the cavity from which the sequestrum has been removed becomes completely filled and cure results. At this time the X-rays avail but little as a means of estimating the degree to which ossification has progressed; a better method is to follow the plan advocated by Nichols (Keen) and operate when a needle passed through the involucrum near a sinus penetrates its inner layers with a crisp, crackling sensation

An incision is made down to the necrotic bone, the periosteum gently turned aside with a sharp rugine, which will lift with it osteoblasts belonging to the outer layers of the bone, and the sequestrum removed by chiselling through normal bone just beyond it. The periosteum, with its attached bone cells, is allowed to fall back, the wound closed, and the limb splinted. New subperiosteal bone fills the space, and ultimately, becoming channelled by a new medullary cavity and moulded by osteoclastic and osteoblastic activities, functionally reconstitutes the limb in about six to nine months.

Where, however, sequestrotomy has been delayed till the involucrum is dense and its regenerative faculties are reduced, the removal of the now completely separated sequestrum is apt to leave a persistent foul central cavity walled in by dense involucrum and closed at either end by a compact osseous plug. The obliteration of such cavities may be attempted in various ways, no one of which is, however, certain in its efficacy. Thus the method of sterilizing the central cavity, breaking down the osseous plug at each end so as to permit a freer blood supply from the healthy marrow, and then filling the cavity with blood-clot in the hope that it will organize, has generally failed, and is not free from danger of necrosis of fresh marrow.

Neuber's very useful plan of removing the whole length of one bony wall of the cavity and turning in skin-flaps to adhere to the bone sometimes succeeds in obliterating the foul cavity, though it does nothing to reconstitute or strengthen the bone.

Mosetig-Moorhof thoroughly cleanses the cavity, dries it, and fills it with a warmed, melted wax made of iodoform 60 parts, spermaceti 40 parts, oil of sesame 40 parts. He then sutures the overlying soft parts. He claims that sometimes the wax is absorbed and replaced by new bone.

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When regeneration of the bone entirely fails, leaving a flail-like limb, the defect may be remedied by the use of orthopædic means of giving mechanical purchase, or the bone may be reconstituted by bone-grafting or by implantation of living bone fragments along a channel made in the muscles.

Total subperiosteal resection and implantation of a bone-graft from the opposite fibula has also been adopted with success.

A *Brodie's abscess* may be treated by any of the above-mentioned methods; the cavity should be opened in a shelving manner, cleansed for two or three days with flavine, filled with muscle-flap or with wax, and then closed by delayed suture. If this fails, Neuber's method is often useful.

Chronic Osteo-Myelitis

This term includes the late stages of acute osteo-myelitis and Brodie's abscess, already discussed; it may also be made to include typhoid osteitis, tuberculosis, syphilitic disease of bone, etc. (*see* below). But, in addition, cases are occasionally seen in which chronic changes are due to an infection with staphylococci, especially S. aureus, of a low grade of virulence. In cases in my experience this micro-organism has been grown from the bone-chips; the cases show fusiform thickening of the diaphysis of a long bone, and aching pain, worse at night, and the skiagrams demonstrate a diffuse bony thickening, either on the subperiosteal or on both subperiosteal and endosteal aspects; in the latter case the medullary canal is often narrowed. They are therefore difficult to diagnose from similar syphilitic changes, but the Wassermann reaction is persistently negative and there are no other signs or history of syphilis; my patients have all been youths between 10 and 20; the affected bones have been femur, tibia, and humerus. They are relieved by exposing the bone through a flap-like incision, gouging a long gutter, and then closing the wound.

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It is also possible that the conditions known as Köhler's disease of the tarsal scaphoid, Schlatter's disease, and the Legg-Calvé-

von Perthes pseudo-coxalgia, are due to infections of low-grade virulence.

Typhoid Osteitis

In connexion with enteric fever, bone infection may be caused by B. coli communis, by staphylococci or streptococci, but also the B. typhosus may, either alone or in association with the pyogenetic organisms, produce inflammatory lesions. The frequency of this complication is variously stated: it occurs in probably less than 1 per cent. of cases of enteric fever; it appears to be commonest before the age of 20, but may occur at any age. Most often encountered in the later weeks of the disease, from the third onwards, it may be found in the first two weeks or may only supervene months or even years after recovery.

the

affec

the temperature rises again, the affected bone becomes swollen and painful. In the earlier stages there may be remissions and relapses. In mild cases

reddened

localized,

are then

worse at nights, and are increased by pressure or by movement. Fluctuation is absent or slight; the amount of pus, if any is present, is usually small.

The underlying con

bone and periosteum;

(c) occasionally an enc

small collection of pus under the periosteum, in a cavity in compact bone or, *in adolescents, in the cancellous tissue not far from the juxta-epiphysial*

chronic cases it may be thin, con-

more commonly it is creamy and

h. In the suppurative forms the bone tends to undergo caries rather than necrosis; sequestrum-formation is therefore unusual but may occur.

Generally one long bone is affected, but very occasionally more than one is attacked. The tibiæ are the commonest victims, but the spinal column, the ribs and sternum are not infrequently involved. In a recent case, the tibia showed a small sequestrum in an encysted abscess, and the ulna a tender bony subperiosteal thickening.

Prognosis.—In the early stages and in mild cases resolution may occur without operation. If a sequestrum forms, or suppuration occurs, incision, cleansing and delayed primary or secondary closure are necessary; *if possible, drainage should be avoided, for it leads to the production of a*

tedious. Danger to life is not great.

at rest and the part fomented.

on, gentle curetting, and either closure or drainage are indicated; if a sequestrum be present it must be removed.

TUBERCULOSIS OF BONE

This condition is considered in association with *tuberculosis of joints* at p. 896.

SYPHILIS OF BONE[1]

Syphilis may manifest itself in bone in any of the following ways:—

(1) *Osteocopic pains.*
(2) *Periostitis.*
- In long bones
  - Localized
    - Shaft nodes.
    - Epiphysial nodes.
  - Diffuse
- In flat bones . . . Parrot's nodes

(3) *Subperiosteal plus endosteal new formation,* leading to osteo-sclerosis of a bone.
(4) *Localized sclerosis.*
(5) *Gummatous changes.*
- Localized, in cancellous bone or under the periosteum.
- [illegible] as in dactylitis.

(6) *Para-*[illegible]
(7) *Craniotabes.*

(1) In the early secondary stage vague fleeting pains (*osteocopic pains*) are not infrequent. They readily react to treatment, and leave no obvious effects.

(2) *Periostitis* and subperiosteal new formation of bone may cause node-formation, especially in the late secondary and early tertiary periods of the acquired disease and in young congenital syphilitics of school age. It generally affects the shaft of one long bone, chiefly the tibia, but may be found in the epiphysis, and then causes much deformity and secondary interference with the movements of the neighbouring joint. Both tibias or both ulnas may be affected.

Thickening and infiltration of the periosteum are followed by deposition of soft new subperiosteal bone, which later becomes dense. Usually only a part of the shaft is affected and the swelling is more or less circumscribed (*periosteal node*). Clinically, the presence of a localized fusiform swelling, especially if over the shaft of tibia, ulna, or other long bone, in a syphilitic patient, and the complaint of slight tenderness on pressure and of a moderate degree of deep aching pain, exaggerated by warmth in bed, will usually lead to the diagnosis; the congenital form is, however, usually almost painless. Suppuration is very rare

Occasionally the swelling, instead of being a localized node, extends diffusely over the whole length of the bone.

In congenital syphilis with periosteal nodes on a growing bone,

[1] *See also* Vol. I., pp. 663, 788, 793, 821

lengthening of the shaft may occur. This is well seen in the tibia, *in which case, the fibula* remaining of normal length, the tibia becomes bowed.

In congenital syphilitic infants, a set of nodes (here known as *Parrot's nodes*) may be seen on the skull, around the margins of the anterior *fontanelle*; they give rise to a peculiar "hot-cross bun" malformation of the cranial vault. Similar nodes may occur on the other bones of the calvarium.

Early and adequate constitutional treatment, while the new bone *is still soft*, will cause disappearance of *nodes, whether on* long bones or on the skull; *but in* cases of longer standing, in which sclerosis has already taken place, the deformity will persist.



Fig. 807.—Syphilitic enlargement of the tibia.

(3) A combination of *endosteal with subperiosteal thickening* of the greater part of a bone, e.g. the tibia, may occur in acquired syphilis (*see* Fig. 807), but is commoner in congenitally infected children, especially those of *school age*. As a result the whole *shaft of the attacked bone, most often the tibia, becomes thick, very* dense, sclerosed and heavy, enlarged and even elongated, and its medullary canal is narrowed. It is usually moderately tender on pressure. It is bowed forwards as in rickets and in osteitis deformans; but it is distinguished from the former by the absence of lateral bending, by its situation in the middle of the shaft rather than near the ends, by the rounded anterior edge, and usually by its later development; while the bone is abnormally heavy, not light as in osteitis deformans.

(4) Localized *sclerosis* of surrounding and underlying bone accompanies subperiosteal new formation and gummata. The resultant narrowing of the Haversian canals and the associated *syphilitic*

obliterative endarteritis diminish the nutrition of the bone, and pave the way for necrosis if pyogenetic organisms gain a footing.

(5) *Gummatous* changes may show themselves as (*a*) localized gummata; (*b*) diffuse areas of gummatous infiltration, e.g. in the skull, or as (*c*) central infiltrations in carpals, metacarpals, or phalanges, giving rise to a dactylitis of the nature of a syphilitic osteo-myelitis, not, in itself, easily distinguishable from tuberculous dactylitis.

(*a*) and (*b*) Localized *gummata* or areas of *gummatous infiltration* may appear in the cancellous tissue or under the periosteum. They enlarge, become infected with pyogenetic organisms from the overlying skin or elsewhere, break down, and may then cause slow but extensive necrosis of the bone. In the skull especially such a process may continue for months or years, and lead to widespread ulceration of bone, perforations, dense surrounding sclerosis, and the formation of large "worm-eaten" sequestra which, owing to the poverty of the blood supply and the density of the limiting sclerosis, may remain but partially separated for years. (Figs. 808, 809.) There is here but slight accompanying subpericranial new-bone formation.



Fig. 808.—Perforation of calvarium, due to separation of a large syphilo-septic sequestrum, with thickening of bone. (*Dreadnought Hospital Museum, Greenwich.*)

Subperiosteal gummata are not uncommon in the sternum, clavicle, or ribs. A soft hemispherical swelling appears over the sternum, becomes red, and bursts, evacuating the contents and leaving a "wash-leather" slough.

In the long bones a localized subperiosteal infiltration may lead to syphilitic caries of part of the cortex, or may form a definite gummatous tumour. There is no necrosis of definite areas of bone or sequestrum-formation unless secondary infection with pyogenetic organisms has occurred.

A gumma may appear in the cancellous tissue of a long bone, either in the epiphysis or at the end of the diaphysis. It may remain quiet for a long period, merely causing some localized caries, shown by the X-rays, or it may involve the neighbouring joint.

(c) In other cases, especially in congenitally infected children, a central gummatous infiltration (syphilitic osteo-myelitis) will cause erosion of the inner compact layers; this, with the simultaneous subperiosteal new formation, will give rise to "expansion" of the bone, and may even lead to a "spontaneous fracture" with crumpling and shortening of the bone. In some cases it resists constitutional anti-syphilitic treatment unless combined with free opening of the medullary canal and removal of diseased tissue, followed by primary closure with sutures. This form of the disease is not often seen except in congenitally infected children, but in them is not infrequent (syphilitic dactylitis). It is commonest in phalanges, which become "expanded," bulbous, and shortened, as in tuberculous dactylitis. The process is almost or quite painless, and is slowly progressive. Ultimately the finger becomes red and tender, and sinuses open into the bone.



Fig. 809.—"Worm-eaten" syphilo-septic necrotic area of calvarium.

The skull trephined to show increased thickness of bone.

(*Dreadnought Hospital Museum, Greenwich.*)

(6) *Epiphysial changes.*—In a comparatively large proportion of fatal cases *post-mortem signs of irregular epiphysial development* will be found; irregular tooth-like processes of cartilage project into the diaphysis. Sometimes the process goes farther—the para-epiphysial

calcified cartilage, especially on the diaphysial side, becomes dull and friable, and a definite *syphilitic epiphysitis* (or *osteo-chondritis*) develops. The disease appears in early infancy, usually under the age of three months, and the enlargement affects not only the epiphysis but also, in a minor degree, the end of the diaphysis, which shows periostitis; in these respects it differs from rickets.

Occasionally the altered cartilage becomes converted into granulation tissue and "spontaneous" separation of the epiphysis follows, causing one variety of "syphilitic pseudo-paralysis" of the limb. The change may even progress to suppuration, which may involve the adjacent joint.

Clinically, the infant cries when the epiphysis is touched or moved, and refuses to move the limb ("pseudo-paralysis"); there is some local swelling, and separation may be palpable; these signs, combined with other evidences of syphilis in the child or its parents, will generally permit diagnosis. The epiphyses usually selected are those near the knees or elbows, or less commonly near the wrists. Several epiphyses may be affected simultaneously.

(7) *Craniotabes*, in which there is localized softening and thinning of the bones, especially the parietals, is probably sometimes due to congenital syphilis, though perhaps only indirectly so as a secondary effect of the associated malnutrition. It usually appears in early infancy (the first six months), and the bone gives a sensation of crackling and undue flexibility on pressure.

Treatment and prognosis.—Under ordinary constitutional antisyphilitic remedies such as mercury, iodides, and novarsenobillon or a similar arsenical derivative, the progress of the disease ceases and the subjective symptoms disappear, as a rule, but if the subperiosteal and endosteal new bone has had time to become dense the deformity will persist. In syphilitic dactylitis the tenderness goes and the sinuses heal, but the fingers remain thickened, bulbous, and shortened.

Gummata will usually disappear. Great care must be taken to prevent secondary pyogenetic infection; if this be present it must be combated by antiseptic measures, and by dressing with ung. hydrarg. nitratis dil.

Carious bone may be curetted and separated sequestra removed, but in the skull no attempt should be made to hasten the separation by chiselling.

KÖHLER'S DISEASE (ISOLATED DISEASE OF THE TARSAL SCAPHOID)

In 1908 this condition was described by Kohler in three cases, and since then many more cases have been reported. The radiographic appearances are characteristic: (*a*) The affected scaphoid

is smaller ($\frac{1}{2}$ to $\frac{1}{4}$) than the normal one. (*b*) The architectural structure is confused. (*c*) The shadow thrown by the bone is twice to four times as dense as normal, but is often patchy. (*d*) The shape is usually regular, but has been irregular in a few cases.

The onset is generally gradual, but may be sudden, and in some cases has been attributed by the patient to a more or less definite trauma.

Practically all the reported cases have been in boys between 3 and 9 years of age; complaint is made of pain and lameness, commonly with tenderness and swelling over the scaphoid; local heat and redness may sometimes be present.

Pathology.—As causes of the condition, *compression-fracture*, tuberculosis, and delayed ossification followed by too rapid osteogenesis, caused by *trauma*, *have been suggested, but may be ruled* out; premature ossification has also been suggested. Possibly in this disease, as in Schlatter's disease of the tubercle of the tibia and in pseudo-coxalgia, the underlying cause is an infection with a staphylococcus of low-grade virulence, and the localization in the scaphoid may be determined by the fact that this is normally the last tarsal bone to ossify; it is difficult, however, to reconcile the complete radiographic recovery with a staphylococcal infection.

Prognosis.—In all cases the tendency is to complete functional and radiographic recovery within from six months to three years.

Treatment.—Plaster of paris may be applied to relieve strain on the inner margin of the foot, and massage to the calf muscles carried out.

RICKETS (RACHITIS)

This constitutional dyscrasia has wide effects through the whole body, but the surgeon's interest largely centres in the osseous system; the many deformities caused are discussed in the article on Orthopædic Surgery (*p. 1017*).

Three forms have been described: (1) fœtal rickets, commencing *in utero*, is probably often osteogenesis imperfecta congenita (p. 761); (2) adult rickets has been confused with osteomalacia, though true *rickets* may perhaps sometimes appear during adolescence (*see* p. 762); (3) infantile rickets is the common form, and will be described.

The **etiology** is not fully determined. Many theories have been held, but most of them are unproved. Thus, the disease has been *attributed to* inadequate assimilation of calcium or of phosphorus, to deficiency of fatty food, to excessive removal of calcium, to alimentary *auto-intoxication*, to syphilis, to microbial infection, to faults in thymus or in parathyroids, and to nervous influences.

The underlying etiology of rickets is the subject of much debate between two schools of investigators. On the one hand, as the result of experimental feeding of animals, Mellanby, Hopkins and others consider it primarily due to a lack of the anti-rachitic accessory food factor or vitamin, fat-soluble A, which is a content of cod-liver oil and fresh animal fats, and which can, to some extent, balance deprivation of calcium and phosphorus in the diet; as the secondary or consequent cause they postulate cereal and carbohydrate excess, and insufficiency of fresh air and exercise, regarding these as factors causing dilution of the vitamin. Mellanby produced rickets in dogs which were getting ample calcium and phosphorus but a deficiency of fat; Korenchevsky produced it in 100 per cent. of young rats deprived of both fat-soluble vitamin and calcium. McCollum and others found, in rats, that deficiency of fat-soluble vitamin caused osteo-porosis but not true rickets, but that simultaneous deprivation of this substance and of calcium, and, especially, of phosphorus, caused true rachitis. In the prevention of the disease in animals, therefore, there seems to be an interaction between the fat-soluble vitamin, the calcium, and the phosphorus.

Cod-liver-oil feeding of children, brought up in circumstances predisposing to rickets, such as the negro child of New York (Hess and Unger) or the artisan's child in Glasgow (Findlay and others), materially reduces the incidence of the disease as compared with that among similar children not so fed; therefore animal fat, or its constituent vitamin, prevents the disease.

On the other hand, Findlay, Noel Paton, Ferguson, Hess, Unger and others regard lack of sunlight, fresh air, and exercise as the causes; they advance experiments and clinical observations in support of their contention. Rats, fed on a low phosphorus diet, regularly developed rickety changes if kept in the dark, but not if exposed to light.

Huldschinsky and others found that ultra-violet rays from a mercury-vapour quartz lamp had curative effects, and later he and Riedel combined the use of sunlight and the ultra-violet rays. Hess and Unger demonstrated the therapeutic value of sunlight alone. Wimberger cited the case of two twins, one fed on a fat-poor and the other on a fat-rich diet; yet there was no material difference as regards bone development. Mackay states that in a London clinic improvement followed fat-rich feeding of rachitic children only in summer. H. S. Hutchison, at Nasik, found that children of high-class Mohammedans and Hindus, living in "purdah" with their mothers, suffered from rickets more than infants of poorer Indians, who, although fed less generously, were free to enjoy sunlight and fresh air.

McCollum and his fellow-workers have recently suggested that there is in cod-liver oil a factor other than fat-soluble A that can

balance calcium insufficiency; they also found that sunlight can replace cod-liver oil as an agent preventing rickets in rats *subject to calcium* deprivation.

The whole question must be regarded as still *sub judice*. At present there is evidence that cod-liver oil *certainly contains a prophylactic* agent, and that a badly balanced diet, including too small a proportion of animal fat, predisposes to the disease; on the other hand there is equally good evidence that confinement, lack of fresh air, sunlight and exercise are factors in the etiology. Both factors are probably important; the two schools of workers disagree, however, as to which is the etiological agent of prime, and which of secondary, importance.

The following predisposing factors are at work in many cases:—

(*a*) The child's age is usually between 6 months and 2 years, the period of the first dentition.

(*b*) Insufficient or unsuitable feeding is very constant: deficiency of fats (so usual in prepared tinned milks) and excess of carbohydrates are especially prominent features. The disease is much more common in artificially fed babies than in the breast-fed, though if the mother's milk be deficient in quantity or quality, or supplied at irregular intervals, it is possible in the unweaned child. Unduly prolonged lactation has been blamed, but is certainly less important than premature weaning.

(*c*) Poverty (except in India) and slummy surroundings, especially if involving insufficiency of sunlight and fresh air, are frequent factors.

(*d*) Gastro-intestinal disturbances are common.

(*e*) Diseases producing inanition, such as syphilis, may predispose to rickets, but have no direct effect.

(*f*) As to geographical distribution, rickets is not seen in native African races, living naturally, though it is common in American negroes. It is very uncommon in Japan, although there the habitual diet is apparently deficient in animal fats.

(*g*) Its incidence is greater in the dark winter months.

Pathology.—The epiphysial cartilage and the adjacent layers of calcified cartilage are each irregularly thickened, and the former is also increased in diameter; both lose their definite boundaries, so that islands and br

calcified parts, and

cancellous bone.

origins of the osteomas and chondromas that later develop near the growing ends of long bones. The line of ossification is an irregular and jagged band of greyish, translucent material with which are mixed gritty white calcified particles and bluish cartilaginous patches. The end of the diaphysis forms a wide cup with concavity towards the epiphysis, instead of being straight. The new bone is unduly

soft, porous and vascular; its periosteum, also very vascular, is easily detached. The medullary spaces in the calcified cartilage and cancellous bone are irregular and unduly large; so are the Haversian canals and spaces of the shaft. The whole bone, therefore, is weakened and softened. An excess of the cartilaginous scaffolding is laid down, but during the disease true bone-formation is defective. Similarly, the subperiosteal new bone of the shaft is slowly and poorly ossified, so that it may be cut with a knife; afterwards, however, the bone may become denser than is normal, owing to the deformity of the bone calling for a response to unnatural strains, thus are perpetuated the deformities developed during the period of softening. Moreover, at this time these strains lead to the production of buttresses across the concavities which often become strongly ossified and give an appearance of lateral flattening. During the treatment of the disease a definite evidence of the progress of cure can be seen in X-ray, in the form of newly-laid-down periosteal bone. The character of the deformities is largely determined in each case by the prevailing attitudes of the patient, predominant pressures, and muscular tractions, and by such accidents as respiratory obstruction during the active period of the disease.

Microscopically, the picture is one of confusion. The cartilage cells of the epiphysial region are seen to have divided irregularly to form disorderly masses and irregular columns instead of even, longitudinal, parallel rows. Calcification of cartilage is absent in places; in others it is scattered irregularly and forms projecting teeth towards the marrow. Although blood-vessels run abundantly from perichondrium into the cartilage, the normal invasion of capillary loops, accompanied by osteoblastic and osteoclastic cells, is hindered, so that cartilage persists where it should not, and the bone formed is soft, and laid down in a rough irregular manner; much of it, although morphologically like bone, is not calcified (osteoid tissue). The marrow is more fibrous than is normal, and may contain islands of cartilage and of osteoid or of osseous tissue.

Clinical features.—During the active period the child sometimes has slight fever, sweats profusely, especially from the head and chest, is fretful, and shows signs of gastro-intestinal disturbance, such as vomiting, capricious appetite, green offensive diarrhœa, or sometimes flatulence and constipation. He is pale, and may be thin, or large, fat, and flabby; his abdomen is prominent, owing partly to gastro-intestinal flatulence and partly to atony of the intestinal walls, and his spleen often enlarged and fairly firm. Nocturnal sweating, restlessness, and dislike of being handled are followed by obvious epiphysial enlargement, and later by curvation of the long bones. The onset is generally insidious and the progress but

subacute. The first dentition is delayed and irregular; this irregularity may be perpetuated in the second dentition owing to the lack of room.

The child learns to walk late, or sometimes, after walking for a month or two, "goes off his feet again."

The *limb* bones become bent, usually in a manner exaggerating the natural curves. In the concavity of the curves new bone is laid down to form struts or buttresses. The lower limbs suffer most: the femur tends to bend forwards and outwards; the tibiæ frequently show, as seen from the front, the bends depicted in Fig 810, whilst from the side the shaft may curve forward or there may be a bend forward near the lower epiphysial region. At the same time the shaft is often spirally twisted and flattened from side to side ("sabre-tibia"). The anterior border of the tibia is sharp, not rounded as in congenital syphilis. The fibula curves with the tibia. *Reduction of the angle*

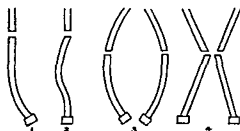


Fig. 810.—Rickety deformities.

1, Outward curve of tibia (originating in sitting posture), 2, ditto, with straightening of the lower end, 3, bow legs, 4, knock knee.

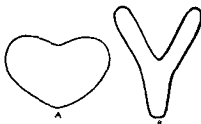


Fig. 811.—Pelvic deformities.

A, Flattened reniform pelvis in rickets; B, triradiate pelvis, usually due to osteomalacia, but also met with in exceptional cases of rickets

of the femoral neck may lead to the signs of coxa vara. In all the long bones the epiphyses tend to be enlarged and clumsy, especially those at the wrists, ankles, and knees. Genu valgum, or less often genu varum, is apt to develop. Ligaments generally are lax, therefore the knees are unstable, and flat-foot is common in walking children.

The *pelvis* is generally flattened antero-posteriorly, sometimes unequally on the two sides, so that an oblique pelvis is established. *If the patient habitually walks during the disease, the pelvis may* be oval or triradiate. (Fig. 811.)

In the *thorax* the enlargement of the costo-chondral junctions causes a beaded appearance ("rickety rosary"), on both inner and outer aspects.

Any associated respiratory impediment causes flattening of the sides of the chest, a straightening of the rib shafts and sharp bending at their angles, a projection forwards of the sternum, and *perhaps a*

lateral grooving of the thorax (pigeon breast). There is frequently a transverse sulcus (Harrison's sulcus) above the costal margin, corresponding in position to the attachments of the diaphragm. The clavicular curves are exaggerated.

The *spine* frequently becomes kyphotic, or less often scoliotic.

The *head* becomes brachycephalic, the forehead prominent and square, and the frontal and parietal eminences unduly obvious and spongy.

The anterior fontanelle is late in closing, and "craniotabetic" patches of softening appear, especially behind and above the ears.

The *teeth* of the first set appear irregularly, are deficient in enamel, and crumble and become eroded early; their edges are sometimes concave.

The *abdominal walls* are lax and prominent and the subcostal angle is often wide. *Skeletal muscles* are flabby.

Complications are common. Gastro-intestinal disturbance is so frequent as to be looked upon as part of the disease. It may be associated with stomatitis and glossitis. Respiratory disease, such as bronchitis and broncho-pneumonia, often occurs; laryngeal spasm and apnœa are less usual. Convulsions are sometimes an alarming feature. Fractures are liable to occur, are usually "greenstick" in nature, and often on the convexity of a bend; they may be multiple. Union is slow and weak, or may fail to occur until the disease is checked. Coxa vara may develop.

Treatment consists in—(*a*) Correction of the faulty diet and hygiene The child must have ample sunshine and fresh air and be supplied with a diet rich in animal fats but adapted to his age and digestive powers. Milk, modified if necessary, must be given in abundance. After the age of 9 months raw-meat juice is often useful as an addition, and in children over 6 months the yolk of a lightly boiled egg daily and, over a year, fresh green vegetables. Carbohydrate foods must be restricted. For gastro-intestinal fermentation small regular doses of grey powder should be administered.

(*b*) Cod-liver oil and malt, with or without syr. ferri phosph co. or the hypophosphites of sodium and calcium, is of great value.

(*c*) The prevention of deformities must be carefully undertaken. If they be present and sufficiently severe, the recumbent position, with or without splints to prevent walking or crawling, should be adopted But in every case the value of exercise must be remembered. Daily massage is advantageous.

(*d*) In early cases much can be done by patient daily manipulation, combined with splints or springs, to correct deformities. In old-standing cases osteotomy or osteoclasis will be necessary.

Although the general methods of treatment are shortly indicated above, every case will require detailed consideration on its own merits.

Adolescent Rickets

Rickets occasionally attacks adolescents, especially those subjected to undue mental or physical distress. The patient becomes pale and listless and the leg bones show a tendency to bend, especially near the epiphysial lines. Supporting buttresses are absent.

Under the title of Endemic or Famine Osteomalacia Fromme has described cases that in the adolescent closely resemble rickets and might have been included under this heading (*see* p. 766).

INFANTILE SCURVY ("SCURVY RICKETS," BARLOW'S DISEASE)

This condition is a scorbutic manifestation perhaps occurring in a rickety child, and attributable to the excessive use of artificial foods and sterilized ... It usually occurs,

extravasations, the position and amount of which determine the seriousness of the symptoms. Often at first sight the child looks fat and of good complexion. The slightest cases may show nothing but a tendency to ready bruising, to bleeding from the gums, or to slight hæmaturia. In the more severe examples the onset may be sudden, the temperature rise to 100° or *even 102° F., and the ends of some of the long bones, especially the femur* and tibia, become exquisitely tender and swollen. A subperiosteal hæmorrhage occurs and extends from just above the joint to some distance along the shaft. The overlying tissues become œdematous, and the skin is at first shiny but later may possibly become stained with blood pigments. The child refuses to move the limb, and pseudo-paralysis results; the epiphysis may even rarely become separated, and occasionally hæmarthrosis occurs. At the same time the child is obviously ill, and is apt to have hæmorrhages from other parts such as the mouth, nose, stomach, bowel, or kidneys. Hæmor- ... have

and

curs

duly

vascular; the underlying bone is rarefied; and although in long-continued cases some new subperiosteal bone may be formed, it is not strong. It is said that the blood shows diminished alkalinity (Wright).

Purpura is often associated, and can be produced, for diagnostic purposes, by the use of a tourniquet.

Prognosis.—Under treatment recovery is rapid, but in a neglected case the child may become emaciated and die.

Treatment.—The essential treatment is to replace in the diet the lacking antiscorbutic properties. Therefore fresh milk, lemon juice, orange juice, citrate of soda, and green vegetables must be given. Raw-meat juice and potato cream (1 dr. every six hours) are useful unless they are found to cause diarrhœa. The local lesions must be treated by cooling lotions and careful splinting.

processes, narrowing of the sella turcica, changes in the *optic discs*, and hydrocephalus

Fractures from trivial violence are a clinical feature of the disease, which is diagnosed from the X-ray showings. No cause is known.

OSTEOGENESIS IMPERFECTA CONGENITA (IDIOPATHIC PSATHYROSIS)

This is a rare condition of defective osteoblastic action during development, leading to undue fragility of the bones.

The **etiology** is quite unknown, but there is an hereditary influence in about 15 per cent. of the cases.

Pathology.—Both at the epiphysial line and subperiosteally the normal development is replaced by the projection into the diaphysis of masses of cartilage cells with unruptured, thickened and calcified capsules. The *cartilaginous scaffolding is often excessively laid down, but true bone-formation is deficient*. Bone-corpuscles are numerous, but are oval instead of stellate, and lamination is irregular or absent. Osteoblasts, though present, are flattened and inactive. Marrow spaces replace Haversian canals and, especially near the epiphyses, contain myxomatous medulla.

Fractures are very common and generally multiple; they may occur in utero, during delivery, or in infancy. Repair occurs, but deformities result.

Clinically, many of the victims are stillborn; when living, they are well nourished but small, and apt to show multiple fractures at birth and associated developmental errors such as club-foot and spina bifida. In view of the probable influence of some internal secretion in regulating-bone development, it is significant that signs of cretinism are sometimes found. The principal clinical evidence is the occurrence of many "idiopathic" fractures during early life. The children often have unusually blue sclerotics. X-rays show general osteoporosis, signs of fractures, thinness of cortex, and deficiency in salts.

Prognosis.—Death usually occurs during intra-uterine life, at birth, or in early infancy.

Treatment consists in carrying the child on a pillow, in the avoidance of the slightest roughness in handling, and in the usual treatment of the fractures. The splints must be very gently and carefully applied.

FRAGILITAS OSSIUM (OSTEO-PSATHYROSIS)

Undue frailty of the bones may be secondary to old age or to any pathological cause of bone absorption, such as the presence of bone tumours, cysts, tuberculosis, trophic nervous disease such as locomotor ataxia or syringo-myelia, or the pressure of extrinsic tumours and aneurysms. In addition, a so-called "*idiopathic*" or "*primary*" *osteo-psathyrosis, congenital* in origin, and closely allied to or, according to some writers, identical with osteogenesis imperfecta, is sometimes seen, numerous fractures from trivial violence occur in one or more members of a family, especially during their childhood. In many cases a definite family influence has been traced, sometim[illegible]

[illegible] orrectly treated.

[illegible] but *osteogenesis imperfecta*, frag[illegible] all one disease, although a few writers reserve the title osteogenesis imperfecta for cases of multiple intra-uterine fractures with imperfect membrane-bone formation, and

retain the name fragilitas ossium for "idiopathic" cases that occur in extra-uterine life.

CLEIDO-CRANIAL DYSOSTOSIS (ANOSTEOPLASIA)

In this very rare disease certain membranous bones become imperfectly ossified. The anterior fontanelle may remain widely patent although the head is not hydrocephalic. The clavicles may be so badly developed that the shoulders may almost be brought together in front. If the child survive infancy the fontanelle closes at about the twentieth year, but the clavicular deformity persists.

OSTEOMALACIA (MOLLITIES OSSIUM)

This rare disease is characterized by absorption of the osseous element of the bones, and by resultant bending and perhaps fracture.

Etiology.—The disease is acquired; 92 per cent. of the cases are in women, and many of them commence during pregnancy or in association with unduly frequent childbearing; some cases begin at puberty. It is relatively commoner in the poor and ill-nourished, and in the Latin races, especially the Italian. It is quite distinct from rickets.

A diet deficient in lime has been held responsible, but is probably not an etiological factor.

The condition will perhaps prove to be due to an excess or alteration of some internal secretion from the genital organs, which acts by dissolving the calcium salts and causing their excretion.

Pathology.—In women the pelvis and spine are most affected, but it is said that in men the long bones are the primary seat of attack.

The bones become decalcified, soft, frail, more or less flexible, and therefore deformed. The periosteum is usually rather thickened, but otherwise normal, and there is generally a thin layer of roughened subperiosteal cortex that remains calcified. The cancellous trabeculæ and much of the compact bone become absorbed or transformed into trabeculæ of bone-like but uncalcified tissue. The marrow becomes soft, vascular, and perhaps hæmorrhagic. Calcium salts are excreted in excess in the urine and fæces; those remaining in the bones may be very greatly reduced, but retain their normal chemical proportions to one another.

The pelvis becomes flattened from before backwards, the promontory falls in, the acetabula are pressed inwards, and the symphysis projects forwards, so that the pelvic cavity roughly assumes the shape of the conventional heart, and later becomes triradiate (Fig 811, B), and so greatly deformed and narrowed as to prevent delivery at childbirth.

The chest becomes narrowed in the lateral and lengthened in the antero-posterior diameters, the clavicles are warped, and the sacrum frequently bends forward. The natural curves of the leg-bones are greatly exaggerated, [illegible]

[illegible]

[illegible]

mally close to the midline, and the lower dorsum is flattened and frequently shows a longitudinal lumbar furrow due to the sinking down of the ribs. The anus sometimes appears to be displaced upwards and backwards, so

The periosteum is thickened and the cancellous tissue rarefied. The *bones* are *light* in spite of their size, thus differing from the thickened bones of syphilitic osteitis.

The *skull* becomes thickened by the *regular deposition of new bone* on the outside. Although thickened, the bone is not condensed but is more porous than is normal. (Fig 812) There is practically no endocranial thickening. As a result the head becomes uniformly enlarged to such an extent that the patient finds it necessary to wear hats of progressively larger size; the temporal fossæ become shallow, and the forehead prominent and overhanging.

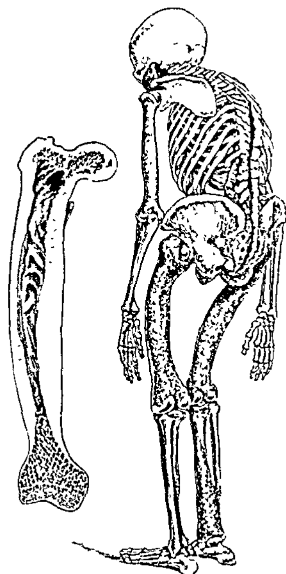


Fig. 813.—Skeleton of a man of 70 affected with osteitis deformans, section of femur from same specimen.

(St Thomas's Hospital Museum)

The *face* usually escapes, but may be affected, especially in the mandible and malar bones, in a minor degree

The *dorsal and lower cervical spine* shows a marked pure kyphosis; scoliosis is rare and, even when present, slight in degree. In extreme cases the affected vertebræ may become wedge-shaped, and there may be spondylitic bony excrescences on the anterior aspects of the vertebral bodies. The *ribs* are thickened and their curves augmented, so that the chest becomes either barrel-shaped or *laterally* flattened.

The *pelvis* usually is but slightly affected, but occasionally in the later stages may become heart-shaped as in osteomalacia. (Fig. 811, A.)

The *hands* and *feet* are slightly or not at all changed. The *long bones* of the limbs, however, show the most marked and the earliest changes. (Fig. 813.)

The *tibiæ*, *femora*, and *fibulæ* are especially attacked, though not as a rule symmetrically, in the early stages at any rate. The "trabecular pattern" of architecture becomes altered and irregular, and the bones thickened and bent, so that the lower limbs are bowed forwards and outwards. The tendency of the bends is to exaggerate the natural curves of the long bones. The changes are at first often more advanced in one bone, for example one tibia, than in the others, and may then cause diagnostic difficulties. The trochanters are prominent and raised, and the femoral angle may be reduced almost to a right angle.

The *clavicles* are sometimes affected, occasionally to an exaggerated degree; they then become enlarged, unduly curved, and very prominent.

Even in young subjects, associated arterio-sclerosis and cardiovascular calcification are strongly developed and may be extreme. In some cases atrophy of the thyroid and suprarenal glands has been noted.

Clinical features.—The onset is very insidious, marked by long-continued, more or less constant bone pains of various degrees of intensity in the long bones, especially of the lower limbs, and occasionally by localized tender spots. In the later stages these both disappear. They may periodically reappear, and are worse when the patient is fatigued. After tiring exercise œdema may appear at the ankles.

The patient may then notice that he requires a larger hat or that he is developing bow-legs, or that a tibia or other bone is becoming unduly prominent and curved. The disease may commence in the head, one tibia, one ulna, one radius, or elsewhere. Sometimes it is for a long time limited to one bone, or the skull, or to one or two limbs. Fractures are rare.

A well-marked case forms a characteristic picture The head is enlarged and projects forwards, the dorsal and lower cervical spine is kyphotic, the lumbar spine appears flattened, and the weakened lower limbs are bowed forwards and outwards. The knees are widely separated, the stature appears diminished, the figure square, the shoulders high, and the arms too long. The gait is extremely waddling, and difficult without the help of a stick, and the attitude "simian"

Neuralgia, headache, and vertigo are occasionally present. Chronic bronchitis is a frequent complication, and deafness, reduction of vision, and mental decay are sometimes associated.

Radiography shows general diffuse, but not dense, increase of

compact bone; sometimes thinner streaks can be seen in it, which represent enlarged Haversian canals; the rarefaction is characteristically patchy. Calcification of vessels can often be seen in the radiogram.

Prognosis.—The disease gradually becomes general and symmetrical, and is slowly progressive during many years, but does not materially shorten life. In some cases life has terminated with a sarcomatosis of bone, sometimes generalized; its exact relationship to the primary osteitis deformans has not been established.

Occasionally "spontaneous" fracture has occurred in osteitis deformans.

Usually it takes from five to fifteen years before the whole skeleton is affected.

The **diagnosis** in an advanced case is readily made from the clinical features. *Acromegaly* is distinguished by the symmetrical nature of its lesions, and by the marked changes in the soft parts and in the face, hands, and feet. In *osteomalacia* the lumbar spine is especially affected, the gait is not waddling, the bones are fragile, and the disease is frequently associated with childbearing. In *arthritis deformans* the kyphosis is due to articular changes, and the shafts of the long bones are unaffected. *Syphilitic enlargement* of the tibia, femur, etc., may be confused with the early changes of osteitis deformans, but may be diagnosed by the history of syphilis, the serum tests, the density of the bone, the absence of bends in the bone, the earlier age of the patient, the reaction to antisyphilitic treatment, at any rate in the earlier stages, and the absence of general enlargement of the skull. *Leontiasis ossea* of the diffuse type may simulate the cranial enlargement of osteitis deformans, but it is said that the overgrowth begins in the face, is internal as well as external, the bony cavities and foramina are narrowed, the eyes are prominent, the patient is young, and the limbs are unaffected.

Treatment is purely symptomatic.

FIBRO-CYSTIC DISEASE (OSTEITIS FIBROSA)

This disease, first described by von Recklinghausen in 1891, closely simulates some myelomas; it is characterized by defective calcification and by the replacement of medulla, cancellous tissue, and part of the compact bone by an inflammatory connective tissue, which is at first spindle- [illegible] recognized, the *local* [illegible]

but may occur in many bones simultaneously; the jaws are [illegible] [illegible]tion of the cases.

[illegible] *g childhood or youth*, though the [illegible] As a rule, the patient seeks advice [illegible]" fractures, or some secondary

tendency to cyst-formation. The cysts may be single or multiple in the same bone; they are often large, especially if single. The contained fluid

There is no surrounding osteosclerosis or subperiosteal new bone. In extensive multiple cases the blood may show the effects of reduction of marrow and the red blood-cells may be greatly reduced.

In the urine there may be excess of calcium and phosphorus; Bence-Jones albumoses are not present.

that, within a period of from two to eighteen years, the patient will either develop sarcoma or will die bedridden with many deforming bone-swellings, and after suffering spontaneous fractures, muscular atrophies, anæmia, and perhaps hæmorrhage from mouth or nose.

See also Bone Cysts, p. 784.

OSTEITIS PLASTICA NON CALCIFICANS

Under this title Pitts and Shattock describe a very rare condition. Part of a bone is transformed into minutely cancellous bone-like tissue which is so devoid of earthy salts that it can be bent and cut with a knife. The shaft

ACROMEGALY

This chronic disease is characterized by a peculiar acquired symmetrical growth-alteration in the osseous and to some extent in other systems, associated with pituitary changes.

Etiology.—Some authors have considered the disease a late syphilitic or a parasyphilitic manifestation, and others have regarded nervous changes

similar to those of tabes dorsalis as of *etiological importance.* Freund, Cunningham, and others noted the anthropoid tendencies, and thought acromegaly an example of atavism; this is only true in that the acromegalic, *the Neanderthal man,* and the anthropoid all show signs of hyperpituitarism (Keith).

The one constant factor is found in the pituitary body, which is enlarged *and hypertrophied. The anterior glandular part* (perhaps chiefly the pars intermedia, described by Herring) probably secretes a hormone, a growth-coördinating substance which controls the balance between hypertrophy and atrophy, possibly by sensitizing the tissues to the stimuli of the stresses and strains applied by muscular action and by pressure. In acromegaly this sensitiveness is *abnormally increased, and the anterior lobe* functions excessively. The disease frequently begins in early adult life; the incidence is about equal in the two sexes. If the disease commences *before union at the epiphysial lines, gigantism is produced.*

Pathology.—The bones are symmetrically thickened and roughened, especially where muscles or ligaments are attached or pressure is borne The surfaces are pitted by the enlargement of the apertures for the emissary veins and other vessels. Osseous hypertrophy is prominent, chiefly in the form of subperiosteal new formation, but also, especially in young skeletons, as intercalated bone. As is so usual, hypertrophy is associated with some trabecular atrophy elsewhere; this absorption is perhaps most obvious in the vertebral bodies, the tarsus, *the angle of the mandible, and the basi-occipital,* and leads to kyphosis, flat-foot, opening out of the mandibular [illegible] magnum.

[illegible] edominate, *other tissues* are [illegible] to increase everywhere; the [illegible] els sclerotic,[1] the subcutaneous [illegible] *The cranial and facial bones* [illegible] imbs are comparatively little changed except in the hands and feet, which are usually greatly enlarged. In the later stages the spine is as a rule kyphotic, and the vertebral centra are compressed The chest is wide, the ribs are thickened, the sternum is broadened, and the pelvis heavy. Everywhere processes, ridges, and surfaces for muscular attachment are exaggerated.

The *cranial and facial skeletal changes* have been carefully examined by Keith. *They may be summarized thus:*—

1. New porous bone is heaped up at the alveolar margins, the dental sockets are elevated, the palatal vault is raised, and the teeth are separated.
2. The *intermolar diameter of the mandible is increased so that the* inferior projects beyond the superior dental arcade.
3. The canines are advanced so as to approximate a transverse line through the incisors.
4. In spite of these changes the actual palatal area, bounded by the alveolar margin and by a transverse line behind the last molars, is not increased.
5. In the body of the mandible growth occurs at the mandibular margin, the mental eminence, and the anterior part of the lower margin. Its ramus is greatly changed; it is narrowed, its angle is absorbed, its height is considerably increased, and the whole mandible is pushed down and forwards by growth at the condyle and the coronary process. The intercondylar diameter and therefore the width of the oro-pharynx are increased.

[1] These changes are well shown in specimens in the Royal College of Surgeons Museum, and in a case at the Dreadnought (Seamen's) Hospital.

6 The origins of the temporal muscles and the temporal ridges spread much farther upwards, backwards, and forwards than is normal, so that the temporal fossa may invade the forehead. Thus a strong sagittal arch, comparable with the sagittal crest of the anthropoids, is developed.

7. The supra-orbital ridges are overgrown and the frontal sinuses expanded.

8. The outer orbital wall moves forward.

9. The zygoma and the external auditory meatus are lowered in relation to the cranial cavity.

10. The nasal prominence is due rather to pushing down by the over-developed supra orbital region than to enlargement of the nasal bones.



Fig. 814 —Acromegaly.

11. The area of nuchal attachment to the occiput is increased, the inion moves upwards (as in the Neanderthal skull), the mastoid processes are wider apart, and the foramen magnum is advanced.

Clinical features.—The face is elongated and coarse, the supra-orbital ridges are prominent, the nose is large, the cranial arch raised, and the head shows apparent lateral flattening (Fig. 814.) The lower jaw is prognathous, the
berant The ears a
flat-foot are frequen
in the viscera and n
result. Nerves may be compressed at their foramina, and bitemporal hemianopsia, exophthalmos, and photophobia are sometimes present The hands and feet are large and coarse. There may be associated gigantism.

Advanced arterio-sclerosis may develop early in life. Impotence and premature menopause are not uncommon; this is interesting in view of the fact that castration may produce signs of hyperpituitarism.

In the late phases muscular weakness may be extreme, and optic neuritis and ocular palsies may be seen.

Stereoscopic radiography sometimes demonstrates enlargement of the sella turcica.

Prognosis.—The disease develops slowly, and may permit life for many years. Cases associated with pituitary sarcoma may, however, end in about two years.

In the later stages of the disease evidences of active hyperpituitarism often cease, and the hypophysial functions appear to be diminished although the permanent bony changes remain.

Treatment other than symptomatic is of little avail. Good results have been claimed for the use of thyroid extract. Cushing secured marked improvement in one case by removing an intrathoracic goitre.

Operative treatment has hitherto improved but a disappointing proportion of cases. Access may be gained to the hypophysis either by the transphenoidal, the frontal, or, less satisfactorily, by the temporal route.

removal of the anterior glandular portion of the pituitary body. If, however, flattened glandular tissue intervenes between the operator and the diseased portion, resort must be had to the frontal or the temporal method. This route, although it gives less satisfactory access, is also often advisable when stereoscopic examination of radiograms indicates that the sella is not expanded. Usually only decompression can be attained by the subtemporal route, but occasionally partial removal is possible. Cushing says that operative measures for acromegaly resolve themselves into—(1) sellar decompression (*a*) for persistent hypophysial headaches, (*b*) to encourage extension into the sphenoid cells rather than into the cranial cavity; (2) partial removal of the hyperplastic gland; (3) subtemporal decompression for pressure symptoms.

HYPERTROPHIC OSTEO-ARTHROPATHY ("PULMONARY")

This condition is usually associated with pulmonary disease. The phalanges, metacarpals, metatarsals, and lower parts of the leg and forearm bones are thickened, and the fingers and toes bulbous, broadened and spatulate, especially near their tips.

Etiology.—Although occasionally seen in a minor form in patients suffering from syphilis, chronic jaundice or diarrhœa, or long-continued

occur in either sex at any age. The changes are probably due to chronic toxæmia, but vascular stasis and insufficiency of some internal secretion have also been held responsible.

and later near the wrists, ankles, or occasionally the knees. Effusion may occur into these joints, but the articular cartilages are not involved.

[illegible] near the extremities of the limbs are most affected.

[illegible]

and longitudinally striated.

The dorsal spine may show kyphosis, and the lumbar region a corresponding lordosis.

The lesions are nearly always symmetrically bilateral. The fingers are clumsy, and there may be inconstant pains in the joints and sometimes in the finger-tips. The general symptoms are those of the primary toxic lesions.

Diagnosis.—The clinical features associated with chronic toxic disease, especially *pulmonary,* will distinguish the condition. From acromegaly a diagnosis can be made by the freedom of the head and face from involvement, by the ungual changes, by the special broadening of the terminal phalanges, and by the undue thickening at the joints.

Prognosis and treatment.—The progress of the disease is [illegible] *but may be checked if the etiological focus can be cured;* [illegible] clumsiness, but its results [illegible] primary disease. There

TUMOURS OF BONE

Angioma

If vascular sarcomas be excluded, very few examples of this condition have been recorded. It is stated that they may be parosteal, periosteal, or osseous *(myelogenous),* but *the last-named variety is especially dubious* as a proved example of angioma. Rokitansky has published a case commencing in the diploë of the parietal bone

Chondroma and Osteoma

These tumours will only be dealt with here in passing, the reader being referred to Vol. I., pp. 414-26, for a fuller account. Here they will be discussed together because, although pure types of each occur, there are also several intermediate types, or osteo-chondromas. The terms chondroma and osteoma are taken to include only new formations *composed of cartilage or bone arising in connexion with bones;* acquired ecchondroses and hyperostoses due to infective or non-infective irritation are excluded, as also, for this article, are cartilaginous and bony growths arising, apart from skeletal bones, in muscles, tendons, ligaments, aponeuroses, or serous membranes.

Clinically certain types may be differentiated:—

1. Ossifying chondroma, single or few in number.
2. Non-ossifying chondroma, also single or few.
3. Multiple chondromas, especially involving the hands and feet, also non-ossifying

4. Multiple osteo-chondromas (including aclasia).
5. Cancellous osteoma of pedunculated type.
6. Compact "ivory" osteoma.

1. *Ossifying chondroma, single or few in number* (*see also* Vol. I., p 415) —This tumour, composed primarily and essentially of cartilage, especially of the hyaline variety, appears at the metaphysis of a long bone of a young person. Probably derived from the epiphysial cartilage, it forms a swelling, composed of one or more knobs, near the end of the diaphysis, especially of the femur or tibia. It shows a strong tendency to ossification, and then develops into a cancellous exostosis such as that to be described below (No. 5). Although usually single in number, in some cases several may be present in the same patient.

2. *Non-ossifying chondroma, single or few in number* (*see* Vol. I., p. 415.—Non-ossifying chondromas are sometimes seen growing from the bones of the pelvis or of the thoracic wall, and by their presence interfering with the organs located in those cavities. They are often large, are lobulated, do not ossify, but often undergo mucoid degeneration with cyst-formation. Rarely a chondroma arising in the metaphysial region of a long bone remains cartilaginous instead of ossifying, and may become cystic and in places myxomatous. Such a tumour may reach a large size, and may then remain apparently unchanged for many years. Such a case is represented in the museum of University College Hospital, in the femur of a girl aged 20; and recently in the wards there has been a woman aged 49 who had had a large cartilaginous tumour of the lower end of the femur which, after remaining stationary for fifteen years at least, had of late begun to grow again and was then a chondro-sarcoma. In both these cases the tumours were large, the compact bone in the neighbourhood had undergone pressure, and there was "eggshell crackling."

Such a chondroma is encapsulated, firm and elastic rather than hard; it may be soft and cystic in places. The distinction from a chondrifying sarcoma may be difficult; but in the recent case described it is difficult to assume that the tumour was a sarcoma during the long period of quiescence.

3. *Multiple chondromas* are to be seen in the centres of metacarpals and phalanges of the hands, and occasionally in the feet. Although, as seen by X-ray, the visible ossific parts of the bones do not appear enlarged and may even seem smaller than normal, the abnormal width of translucent space shows the increase of cartilaginous material. By their growth they greatly expand and deform the bones, of which several may be involved. They may show some calcification, but rarely ossify. They are not derived from the articular cartilage. (*See also* Vol. I., p. 416.)

4. *Multiple osteo-chondromas* (*aclasia, dysclasis, chondro-dysplasia, multiple cancellous osteomas*) are often hereditary, and sometimes appear in several members of the same family and generation. They occur in the usual sites of exostoses, but are also liable to affect the short and the flat bones. They may be very numerous; in one case of my own, in a boy of 4, there were 217 separate osteomas, affecting the phalanges of both feet and hands, the metatarsals and metacarpals, the tarsals and carpals, most of the long bones of the limbs, several ribs, the clavicle, and the occipital. One of the metatarsal exostoses had been removed (? incompletely) by another surgeon; at the site of operation there had formed a large mass of bone which interfered with walking and required complete removal. The father had had several exostoses.

When they involve long bones in the neighbourhood of joints osteo-chondromas may very materially deform the shape of the joint so that the articular surfaces are displaced into abnormal planes. The curious fact has been noted, very clearly in some of my own cases, that the condition sometimes rigidly confines itself to one sex in the affected family; the affected members are stunted in growth, rarely more than 5 ft. in height, while the brothers or the sisters, as the case may be, are of full stature; in one family under my observation four sisters are under 5 ft. in height and all present osteo-chondromas, the brothers are over 6 ft.; the condition appears to be presenting itself in the female baby of one of the affected sisters. The change is probably one of disorderly growth in the region of the metaphysial cylinder of ossifying cartilage. Keith suggests defects in the periosteum, which cause localized failures by that membrane to exercise its normal control over the growing bone; if so the condition is not one of true neoplasm-formation; the names aclasia and chondrodysplasia have also been suggested for this deforming hereditary disease.

If removal of any of these multiple osteo-chondromas be demanded by circumstances before adolescence, it must be done completely, for interference, unless thorough, may stimulate growth; the whole of a carpal or metacarpal, or the whole affected end of a long bone, should be removed.

It has been stated that sarcomatous change sometimes supervenes.

5 *Cancellous osteoma* (*spongy exostosis*) (*see* Vol I., p. 421) arises by a process of ossification in a chondroma of type No. 1 which probably arises as a detached "rest" from the epiphysial cartilage. A slowly growing cancellous osteoma, unless pressing on important structures, such as the popliteal vessels, or producing obvious disfigurement or disability, need not be removed; cessation of growth at or before the time of ossification if the parent epiphysial line may safely be

predicted. Whilst chiselling away an exotosis, the surgeon must remember (1) that in a growing patient the cartilaginous cap must be entirely removed or recurrence will probably ensue; (2) that the overlying bursa, if present, may communicate with the neighbouring joint, and that the opening into the latter will need repair; and (3)

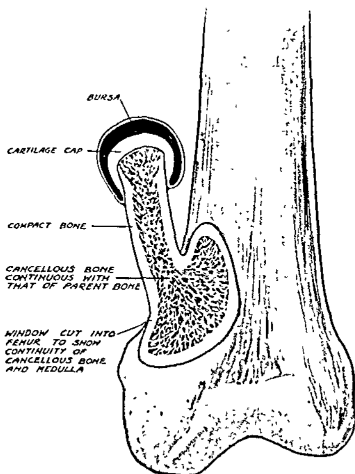


Fig. 815.—Diagrammatic representation of exostosis of lower end of femur.

that the central cancellous tissue of the exostosis is continuous with that of the diaphysis. (Fig. 815.) Occasionally a serous or hæmorrhagic effusion into the overlying bursa is the first indication of the presence of the osteoma; if operation be proposed, care must be taken to make sure that the bursa has not already become infected.

Commonest on the long bones (Plate 133, Fig. 1), osteomas, especially if multiple, may also develop on the short or the flat bones.



Fig. 1.—Large exostosis in region of lesser trochanter in boy of 11, resulting in straightening out of angle of femoral neck and over-development of neck. The leg was 1½ in. longer than its normal fellow.

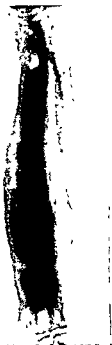


Fig. 2.—Later stages of acute osteo-myelitis of whole shaft of radius.



Fig. 3.—Myeloma of head of humerus.

Fig. 2 shows well-marked involucrum pierced by cloacæ and enclosing large sequestrum of original shaft.

PLATE 133.

They tend to grow along the line of least resistance, hence they generally lie obliquely along the direction of the longitudinal [illegible] and muscular planes, and are attached to the bone at an acute angle. (Figs. 815, 816.) The ordinary cartilage of a [illegible] does not become adherent to the [illegible] tissue. The subungual exostosis is, however, an exception in this matter.

The *subungual exostosis* is especially to be found under the nail of the great toe or that of the fifth toe; this localisation suggests that



Fig. 816.—Multiple osteomas in lower end of femur.
(Dreadnought Hospital Museum, Greenwich.)

injury may have had a share in its production. It forms a small, cherry-coloured, rounded swelling, and causes much pain; it is best treated by *removal* of the nail, incision of soft tissues, and gouging away of the tumour.

6. *Ivory exostoses* (Vol. I., p. 423) are especially found on the skull and face; the regions of the frontal sinus, of the external auditory meatus, and of the cranial vault, are the most favoured *localities*; they may be multiple, and are often more or less *lobulated*. They are covered with periosteum, and probably develop in membranes. They may cause serious symptoms and death by their pressure, *but* occasionally have undergone natural cure by necrosis and separation

by sloughing. Surgical removal should be done by chiselling through the surrounding normal bone and not through the extremely hard tumour itself.

Fibromas of bone are discussed in Vol. I. at p 407.

Myeloma

Although often classified as a sarcoma, a myeloma is a benign growth, increasing very rapidly locally often to an enormous size, but showing no tendency to spread far up the bone or to cause secondary deposits in viscera or lymphatic glands. Exceptional cases have been recorded, however, by Shattock and by Ange and Roux in which a tumour that microscopically presented the characteristics of a myeloma nevertheless gave rise to fatal and distant metastases. It is discussed in Vol I. at p. 431. The onset may be insidious and the patient's attention first attracted by any one of the following symptoms: pain, a sense of local heat, spontaneous fracture; or by the discovery of a tumour, especially if the affected bone be superficially placed.

Radiography (Plate 133, Fig. 3) shows an area of translucent "expansion" stippled with darker points of calcification. This area usually has clearly defined margins, thus differing from that found in true endosteal sarcoma. Occasionally it can be seen that the medullary canal is shut off by a layer of dense bone Spontaneous fractures are particularly common in myeloma.

Sarcoma

Setting aside endosteal myeloma, the sarcomas of bone (Figs. 817–19) may be classified thus:—

Endosteal true sarcoma	Spindle-celled. Round-celled.	In any of these, cystic, myxomatous, fibrous, cartilaginous, or bony changes may occur.
Periosteal	Spindle-celled. Round-celled	

Parosteal—in relation with the outer layer of bone. This latter variety is not really a bone tumour, but is more often associated with the aponeuroses of the part.

For a discussion of the pathology, clinical features, and treatment the reader is referred to Vol. I, pp. 528-35; for treatment by Coley's fluid, to Vol. I., p. 500; and for the radiographic appearances, to Vol. I, pp. 531, 665.

The results of treatment of bone sarcoma, apart from myeloma, are very bad. The amputation should be made to remove the whole of the affected bone and of the muscles and aponeuroses that play over the part. Thus, for sarcoma of the femur an anterior racket

amputation at the hip, combined with removal of the muscles close to the pelvic girdle, is to be preferred to any method, such as Furneaux Jordan's, that leaves a bulky muscular stump; for sarcoma of the upper end of the humerus, Berger's interscapulo-thoracic amputation is to be adopted. In spite of this width of removal, most cases recur.



Fig. 817 — Periosteal sarcoma which has ruptured through the periosteum and into the medulla of the bone.



Fig. 818 —Osseous "skeleton" of periosteal sarcoma of femur which eroded the bone.

(*Dreadnought Hospital Museum, Greenwich*)

Occasionally the bone with all its attached muscles (e g the fibula) has been excised, but this can seldom be considered adequate

Metastases are common, and sometimes early; therefore, before submitting the patient to a severe operation, careful search must be made in other bones and in the viscera for secondary growths

Thyroid tumours of bone especially tend to involve the cranium and the vertebræ; Fig. 820 shows metastasis in the vertebral column in the case of thyroid cancer described in an earlier article (*see* Figs. 668 and 669, pp 220, 221). They may be so vascular as to be strongly pulsatile.



Fig. 820.—Metastasis in vertebral column; same case as Figs. 668, 669, pp. 220, 221.

Prostatic metastases in bones are discussed in Vol. I., p. 591.

For *carcinoma and sarcoma of the jaws* the reader is referred to Vol. I., p. 569, and Vol. III., pp. 638, 641.

Simple Cysts of Bone

These cysts are occasionally seen, especially in the shoulder end of the humerus and in the tibia. *Enlargement of the affected part of the bone occurs insidiously, often quite painlessly, and may be unobserved until "spontaneous" fracture occurs to attract attention to it.* Such a bone may unite, perhaps again to break without ade-

quate cause. On X-ray examination of such a cyst there is found a false expansion of the bone combined with thinning. The thinned area is uniformly clear, and thus differs both from sarcoma and from myeloma.

The condition may be local, but in some cases it appears to be a cystic change occurring in the course of osteitis fibrosa (*see* p. 770).

On incision, the shell of bone is thin, and the cyst lined with fibrous tissue and filled with a serous fluid.

Diagnosis of the nature of the swelling or the cause of fracture is made by radiography and by incision.

Treatment consists either (1) in removal of the affected part of the bone, followed by deliberate re-union of the shortened bone or by bone-grafting; or (2) in free opening, evacuation, and curetting, followed by careful packing to ensure healing from the bottom by granulation tissue.

Hydatid Cysts

Hydatid cysts (*see* Fig. 170, Vol. I., p. 633) may appear in cancellous bone anywhere; they differ from those elsewhere in that the mother cysts are absent and the mass consists of a conglomeration of separate daughter cysts. In time the pressure causes expansion and thinning of the compact bone, deformity, and perhaps "spontaneous" fracture.

Diagnosis from other endosteal tumours, in the absence of known hydatid infection, will usually only be made by exploratory incision.

Treatment consists in free opening of the bone and complete removal of all the disease. In advanced cases, with much involvement of the solid bone, amputation is necessary.

Cystic degeneration may occur in malignant disease of bone, as elsewhere: such cysts require no special description in these pages.

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FRACTURES

By ERNEST W. HEY GROVES, M.S., F.R.C.S.

C[illegible] [illegible] y be classified [illegible] reak is usually [illegible] " and " pathological " merely indicate that trauma was only a minor or secondary cause.

Spontaneous and pathological fractures.—Sharp demarcation between these two varieties is impossible, but many surgeons use the term " spontaneous " for a fracture associated with some general disease such as osteomalacia, and " pathological " for one caused by local disease of the bone such as a sarcoma. Accordingly, in the following group the first four would be regarded as spontaneous fractures and the last three as pathological.

1 **Fragilitas ossium and osteogenesis imperfecta congenita** cause multiple fractures in children, but are practically never recognized except by the occurrence of such fractures (*see ante*, p. 764). The tendency to frequent fractures may be seen at birth, and continues until puberty, when it usually ceases. Repair after fracture is rapid and normal.

2. **Nerve conditions.**—In various diseases of the brain and spinal cord, particularly those associated with posterior sclerosis, there is a pronounced tendency to fracture. In tabes, syringomyelia, general paralysis of the insane—the nerve diseases commonly associated with neuropathic fractures—there is a very marked loss of muscular sense and of painful sensation, and the fractures probably often result from awkward, clumsy movements and from lack of appreciation of pain that would put a normal person on his guard. There is no known alteration in the bones, and repair after fracture is quite normal.

3. **Atrophy.**—This is the common cause of the fractures that occur in old people.

Any bone may become atrophied either from disuse or from paralysis. As a cause of spontaneous fracture, however, atrophy is only commonly associated with fracture of the neck of the femur ; the framework of the bone may be reduced to a very thin shell and the interior may be filled with fat. Union in such a bone will be slow and uncertain.

4. **Osteomalacia.**—Rare in this country, but much commoner in Italy, osteomalacia attacks adult pregnant women. It is supposed to be due to an altered internal secretion of the ovaries, causing an excessive excretion of calcium salts. The bones of the skeleton, including the pelvis, become softened and bend or break.

5. **Scurvy rickets.**—The common type of rickets, although leading to the bending and softening of the bone, does not cause fractures, but in

[1] Many of the illustrations in this article are borrowed by permission from the author's " Modern Methods of Treating Fractures " (John Wright & Sons, Ltd).

fœtal and scurvy rickets there is a distinct tendency separation of the epiphyses.

6. Inflammatory bone disease.—All inflammat bone tend to destroy its substance. But the more acute i extensive necrosis of the shafts of the long bones, are usuall so much new-bone formation that there is an ultimate gain i strength.

It is in the chronic bone diseases, caused by *tuberculosis* an by *syphilis*, that the insidious destruction of bone takes plac a loss of continuity. But in such cases the underlying conditi rise to characteristic symptoms of disease, and loss of c occurs, is more in the nature of a slowly developing deformi abrupt fracture. Very rarely a gumma may attack the shaft and cause a spontaneous fracture. Its presence is often not s after the fracture has occurred, as it gives no very charact appearance.

7. New growths of bone.—All long bones, as well a bræ, are liable to new growths, either primary or secondary.

Sarcomas in the bones are usually primary, and often destroy duce an obvious tumour before any fracture results. In deep situations, however, such as the neck of the femur, the first sym primary sarcoma may be fracture following some very trivial i comparatively young adult.

Myeloid growths may be multiple in the long bones and may ca fractures; in these circumstances the Bence-Jones albumose is usua found in the urine and a fatal cachectic condition supervenes.

Carcinoma, which is always secondary, is a comparatively common spontaneous fracture in elderly patients; the primary seat of the dise be an atrophic scirrhus of the breast (Plate 134, Fig. 1) or an unsu cancer of the prostate. Fractures due to metastatic carcinor myeloma will usually unite with a fair amount of callus-formatio those due to a primary sarcoma show no tendency to union.

Lastly, certain *cysts* of the bone may first reveal themselves by cau fracture, e.g. hydatid cysts and the so-called fibro-cystic disease (Plate Fig 2)

The suspected nature of any of these spontaneous or pathological fract must not be allowed to interfere with treatment directed towards the storation of function. A despairing mental attitude, allowing the limb unite in a position of gross deformity, adds unnecessary crippling to already overburdened life, and is inexcusable.

Traumatic fractures. Predisposing causes.—Certain co ditions of age, sex, and occupation predispose to the occurrence of fractur Thus, in childhood the bones are incompletely ossified, in old age they ar brittle and atrophied; males, and those engaged in dangerous and laboriou pursuits, are likely to break bones; old women are particularly prone to fractures of the lower end of the radius and the neck of the femur. All those conditions already described as causing spontaneous fractures will also predispose to the occurrence of traumatic fractures.

Exciting causes.—Traumatic fracture may be due either to an external force or to internal muscular violence. External force may be either direct or indirect. In the former, as when a leg is run over b wheel, the soft parts over the bone will be severely i broken more or less transversely at th



Fig 1 —Spontaneous fracture of femur secondary to carcinoma of breast



Fig 2. — Spontaneous fracture of humerus due to osteitis fibrosa



Fig 3 —Comminuted fracture of tibia and fibula due to direct violence.



Fig 4 —Oblique fracture of tibia due to indirect violence

PLATE 134

Fig. 3), but as a rule the fragments will not be much displaced. If the injury takes the form of indirect violence the force is transmitted through other parts of the body to the affected bone, as [illegible] result of a fall upon the outstretched ha[illegible] indirect violence show no bruising of the [illegible] ecchymosis may appear after the injury. [illegible] with much displacement, and if two adjacent bones in a limb are fractured they will not be broken at the same level, but rather at the weakest points in their shafts. (Plate 131, Fig. 4.)

Fractures due to muscular action include those of the olecranon and patella, both comparatively common, and, more rarely, of the tubercle of the tibia and of the lesser trochanter of the femur.

In all these cases the fracture involves cancellous bone and the fragments are widely separated.

Varieties of traumatic fracture.—Fractures have been variously classified according to the presence or absence of an external wound, the nature of the causative force, and the character of the fractured surfaces.

1. In relation to external wounds.—Fractures which have no communication with the external skin or an internal mucous surface are described as *closed* or *simple* fractures. Fractures which communicate with the skin or a mucous surface are called *open* or *compound*. In the former case, if the bone fragments be placed in good position, union usually takes place quickly and firmly, and septic inflammation is very rare In the latter, a greater or less degree of sepsis is the rule; this may only delay union, or it may cause so much loss of bone that union is impossible, or it may even necessitate amputation of the limb.

2. In relation to the causative violence.—From this point of view it is useful to recognize four simple varieties. *Traction* fractures practically correspond with fractures from muscular violence. *Compression* fractures are best seen in the vertebræ or in impacted fractures of the cancellous ends of the bones when the spongy structure of the skeleton is crushed together in the direction of the injuring force. *Flexion* fractures are caused by one of the long bones being bent over an obstacle or by the two extremi- [illegible] ... The bone [illegible] ...elasticity, as for example when a man, falling from a height, alights on one foot while the weight of his body twists round; thus breaking the tibia in a long spiral fracture.

3. In relation to the shape of the broken ends.—*Incomplete* fractures are those in which there is no absolute loss of continuity, e g. the *green-stick* fractures so common in childhood, especially in rickety children. The bone becomes bent, split longitudinally, and splintered in the convexity of the bend. *Fissured* fractures present a mere longitudinal split, generally near a joint surface.

Impacted fractures.—In these one portion of the bone is driven into another, usually the dense shaft being driven into the more open extremity of the bone.

Complete fractures may be described according to the character of the fractured surface as transverse, oblique, or spiral. If the bone is broken into several fragments it is called *comminuted*. If one wedge-shaped small fragment and two large fragments are present, it is described as a *butterfly* fracture. It is said to be *complicated* when the fracture is associated with an injury of some other important structure, such as an artery or a joint.

4. Separation of the epiphyses.—Injuries of limbs which in adults would produce articular dislocations, in patients under 20 frequently cause so-called separation of the epiphyses. Such a separation is very rarely exactly in the line between the epiphysis and the diaphysis, but

traumatic fracture of the extremity of one of the long bones. The fractured surface of the epiphysis is usually concave; the periosteum, which is closely attached to the margin of the epiphysis, may be stripped off the shaft and the broken portion of the shaft may be thrust through it, so that it forms a

not properly corrected, growth of the affected bone will be seriously impaired, particularly in those epiphyses of the shoulder, wrist, and knee which are chiefly responsible for the growth in length of the long bones. The epiphyses commonly affected, in order of frequency, are the upper and lower ends of the humerus, the lower end of the radius, and the lower end of the femur. The diagnosis, signs, and treatment of these injuries are so similar to those of fractures of the articular ends of the adult bones that it will not be necessary to describe them individually. But separation of the head of the femur is different from other epiphysial separations in that the head has to bear such a heavy weight and is obliquely placed on the neck of the femur, so that a comparatively trivial injury may disturb the junction between the head and the neck and cause displacement of the epiphysis and consequent deformity of the upper end of the femur. This is the so-called "slipped epiphysis." The upper epiphysis of the tibia is rarely, and other growing ends or projections of the bones still more rarely, separated by trauma.

Signs and symptoms of fractures.—Fractures of the long bones are usually accompanied by well-marked signs of injury associated with the loss of skeletal support, deformity of the bone, and *damage to the soft parts*; but these *signs* may be insignificant, or altogether absent, when the fracture takes place in a deeply covered bone ... shock and ... ly be ... to 100° F. for several days. In addition to the external bruising and the pain with loss of function usually found in all complete fractures, three cardinal signs accompany the loss of continuity in the limb bones.

1. **Unnatural mobility.**—The limb appears to have a joint where it ought to be rigid; evidence of this is only obtained just after the accident when the patient is but partly conscious, or at a later date when the early pain of the fracture has passed off.

2. **Crepitus.**—The broken ends of the fragments can be felt or even heard grating upon one another when the limb is moved. Crepitus should not be deliberately sought, because it is accompanied by pain and injury. Near joints the creaking of osteo-arthritis or the finer crepitation of teno-synovitis may imitate the crepitus of a fracture, and, over the chest, surgical emphysema may be confused with the grating of a fractured rib.

Crepitus may be entirely absent in impacted fractures or those in which the fragments are widely separated by interposed soft parts.

3. **Deformity.**—The fragments of a broken bone become displaced by the action of the original violence, by the weight of the limb, by the contraction of the muscles, or by manipulation of the parts in moving the patient. The displacements of the fragments, however caused, are conveniently classified thus:—

Alteration in length.—(*a*) Shortening. The two main fragments of the bone overlap one another, largely because of the contraction of the surrounding muscles. (*b*) Distraction or lengthening This is commonly seen in the patella or olecranon where a portion of the bone has been pulled off by muscular violence.

Alteration in axis—The two main fragments become angulated towards one another; when the fracture is near the articular extremity of the bone the line of the joint is thereby seriously altered.

Rotation.—In the lower limb this is of chief importance because the foot is misplaced with the rotated distal fragment; in the forearm, rotation may interfere with pronation and supination of the hand.

Lateral displacement.—In this the two main fragments lie out of line with one another whilst maintaining the original axis of the bone.

Several varieties of displacement usually coexist in the same case. [illegible]

symmetrical position, and corresponding bony points must be taken from which to make the measurement. Second, the axis of the limb must be noted in order that any angulation of the bone may be detected. This is of particular moment when dealing with a deeply seated bone like the upper end of the femur, because very trivial alteration in length may be accompanied by an important alteration in angle which has a profound effect upon the function of the limb in walking. Third, the alteration of the relative position of the bony points around a joint will give indication as to displacement of the articular end of the bone.

X-rays in relation to fractures.—All signs and symptoms of fractures are comparatively unimportant in diagnosis as compared with the evidence given by the X-rays. It is quite unjustifiable to subject a severely injured patient to long, detailed

examination in order to get information which can be obtained painlessly and much more accurately by means of the rays. Every patient who has received a severe injury to the joints or limbs must be examined radiographically; neglect of this rule is only justified if the necessary apparatus is inaccessible or the patient's general condition threatens a fatal issue.

Radiograms are equally necessary to demonstrate the presence of a fracture, its nature, its progress under treatment, and its ultimate condition. Unfortunate results, such as slow return of function, or serious displacement due to premature use, may follow failure to diagnose certain lesions, such as incomplete fractures, or impacted ones near joints, which cannot with certainty be detected without the use of X-rays. A proper decision as to treatment can only be made when radiography has demonstrated the nature of a fracture and its relation to neighbouring joints. Progress under treatment should be radiographically watched to see that the displacement remains reduced and that proper union and remodelling are taking place. Failure to observe this precaution has led to unfavourable medico-legal decisions.

Certain rules ought to be followed both in the taking and the interpretation of radiograms of a fractured bone. The whole injured region should be photographed, or at least examined by the fluorescent screen, lest in a large bone like the femur the plate taken should miss the fracture altogether. The site of the fracture having been located, either stereoscopic views should be taken, or at least two pictures in planes approximately at right angles to one another; only so can be ascertained the positions of the fragments relative to one another in more than one plane. Two points in the interpretation of the X-ray picture must be remembered. First, that very considerable deviations from the normal are quite consistent with a good functional result, if only the length and alinement of the bone are preserved; thus lateral deviation of the fragments by itself is a matter of little moment. Second, that the tissue of bone repair for a long time gives no shadow with the X-rays, so that a fracture may be firmly united although its uniting callus cannot be seen in the picture.

Complications.—Delirium tremens may follow any accident or injury to an alcoholic patient, but it is particularly frequent after a severe fracture. It is therefore desirable to avoid any complicated or operative treatment until the danger of delirium is over.

Fat-embolism undoubtedly occurs in many cases of serious *fracture* which have a fatal issue; in patients who die shortly after an extensive fracture it is usually possible to demonstrate globules of fat in the small vessels of the brain, lung, and liver. It has been commonly supposed that this circulation of free fat in the blood has itself been a fatal factor; thus it is commonly said that fat-embolism may present a

cerebral or a pulmonary type, the patient in one case suffering from delirium and coma and in the other from bronchitis or pneumonia. It is, however, very difficult to credit the few drops of scattered fat with the power to cause such an extensive block in the circulation.

Local complications of a fracture consist in coincident injury to the surrounding structures. By far the commonest and the most important is injury of the *skin*, making the fracture open, or compound. The importance of this complication will depend upon the degree of sepsis accompanying it and the period at which it comes for treatment. Involvement of the *joints* may form a primary or a secondary complication; the fracture may run into a joint and cause deformity of the articular surface, or dislocation of the joint may be associated with a fracture of the shaft, these both being primary complications. Later, alteration of the line of the joint surfaces may cause deformity, such as flat-foot after fractures of the ankle-joint, or injury to the articular cartilage may be followed by osteo-arthritis. Injuries of *blood-vessels* are decidedly rare in association with fractures, except in the case of gunshot wounds.

Injuries of *nerves* may be induced by the same original fracturing force, or by trapping of nerve-trunks between splintered fragments of bone Late nerve involvement is usually attributed to the nerve being caught in callus, but this is doubtful. The musculo-spiral nerve may be injured in association with fractures of the shaft of the humerus, the external popliteal nerve with fractures of the neck of the fibula, and the brachial plexus with fracture of the clavicle Other complications of nerves with fractures are rare.

Repair of fractures [illegible]

struction or removal of old bone

1. Repair by blood-clot and granulation tissue.—The broken bone-ends and the torn tissues surrounding them become embedded in blood-clot which in the course of a day or two is infiltrated by leucocytes, and later by fibroblasts and plasma and other cells. This cellular mass, in which new capillary blood-vessels are soon developed, is granulation tissue, in which a large number of cells are derived from the osteoblasts of the injured bone and calcium salts are deposited by them in the intercellular material. Thus [illegible]

processes This first stage of repair, from the first pouring out and clotting of blood to the formation of calcified granulation tissue, or pro-callus, occupies a period which varies between six and twelve days in favourable cases.

2 Callus repair (Fig 821, *a*) —In the intermediate stage of repair the

... as callus. ... end-to-end apposition there is a small spindle-shaped mass of callus outside the bone and underneath the periosteum ... "external callus." The interior ... material called "internal callus," ... bone lies a small amount of tiss... ternal and internal callus, which ultimately are entirely removed, are sometimes described as provisional callus. But this is an unnecessary and misleading term, because all callus is provisional and but an intermediate stage between granulation tissue and bone. The callus grows by the further deposit of bone salts by the osteoblasts around the blood-vessels; the change from callus to true bone is so gradual that every grade of the tissue intermediate between the one and the other may be seen in one specimen. From a practical point of view the reparative tissue is regarded as callus so long as it is comparatively rich in blood-vessels and cells and comparatively poor in bone salts. It can be cut with a knife and can be broken away from the adjacent bone. The stage of callus repair occupies about six to twelve weeks in favourable cases.

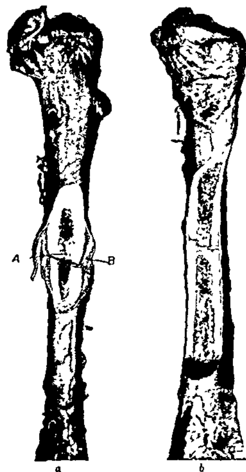


Fig. 821.—Repair of fracture.

a, Cat's tibia 21 days after fracture, showing internal callus (A) and external callus (B). *b*, Cat's tibia 57 days after fracture, showing disappearance of external callus.

3. **Ossification.**—The final stages of repair consist chiefly in the dense portions of the bone becoming more open in texture while the callus becomes denser until the two structures come to be of the same consistence. The bone cells in this process play a double rôle, and it is thought by some that there are two distinct kinds of cells concerned in the process; thus the osteoblasts are the small cells like fibroblasts which lay down new bone and solidify the callus, while the osteoclasts are large multinucleated cells which eat into the dense bone, forming little indentations known as Howship's lacunæ, so rarefying the dense bone. When the two or more bone-ends have become united by callus and their structure is homogeneous with that of the callus, then the last stage of ossification begins. This is of a twofold nature: firstly, those portions of the bone which are to form the dense tubular portion become more and more solidified by a further deposit of bone salts,

until at last a tissue is formed which is rather denser than the original bone broken; secondly, all the unnecessary and exuberant callus, both external and internal, and also projecting angles of bone, are slowly absorbed and replaced by simple fibrous or fatty tissue. The ossification period of repair occupies from six to twelve months.

Modifications in the process of repair.—There are three principal modifications in the method of repair, which are determined by (1) the accuracy of apposition, (2) the amount of comminution or displacement, and (3) the occurrence of suppuration.

1. Healing with good apposition (Fig. 821).—When the fragments are in contact end-to-end, with no appreciable gaps to be filled and no irregularities to be smoothed, then the amount of reparative tissue, whether granulation tissue, callus, or new bone, is very small, being merely the cement material necessary to fill the crack between the bone surfaces This may be described as analogous to healing by first intention, and it will be characterized by rapidity, a minimum of callus, and a perfect result.

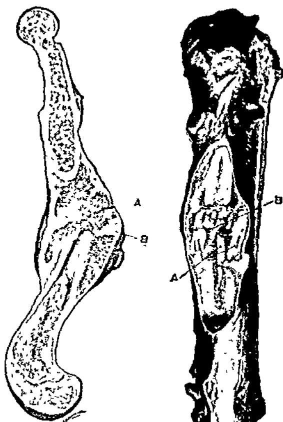


Fig. 822.—Malunion of rabbit's femur after three weeks, showing exuberant callus.

A, Ossified callus. B, Callus which is still cartilaginous.

Fig. 823.—Cat's tibia four weeks after comminuted fracture, showing fragments embedded in callus.

A, Small fragments of bone. B, Callus growing from these fragments.

2. Comminution and marked displacement.—If the fragments are not accurately replaced in close apposition, or if the bone is comminuted, the amount of callus will be large and the time occupied by remodelling prolonged (Figs. 822, 823) This type of repair may be likened to the repair of the soft parts by granulation tissue. Considerable gaps and spaces, including all the receding angles between the fragments, have to be filled with callus. All pieces of dense bone which project beyond the line of the tubular structure are gradually eaten away by the osteoclasts. The final stage of remodelling

of the bone often stops short at complete restoration of the original structure, and a permanent thickened deformity results.

3. **Healing with suppuration.**—In open septic fractures, particularly if comminuted, the process of healing may be delayed indefinitely. The actual course of events will depend upon the degree of infection, the amount of bone injury, and the period after the fracture at which infection becomes serious. Thus, in a gunshot fracture with massive infection and extensive injury of the parts, no healing will occur, but, on the contrary, destructive processes, such as necrosis of bone, septic thrombosis of blood-vessels, and sloughing of muscles and fascia. In a less virulent infection the early stage of granulation and the transformation of granulation tissue into callus will take place, but the reparative process will be very slow and feeble until the infective agent has been eliminated or overcome by natural tissue resistance aided by surgical drainage.

In the presence of sepsis, a very large proportion of the osteoblasts and the plasma cells, which under healthy conditions would effect repair, are killed by the infective toxins and are discharged as pus cells. Moreover, the fragments occupying the septic wound undergo more or less necrosis, their own scanty blood-vessels and tissue cells being quickly destroyed or strangulated in the narrow Haversian canals of the bone. Thus sequestra are formed, around which the delayed repair takes place, and their separation from the living bone and their extrusion, by natural processes or by surgical operation, become necessary. If this removal of dead bone be long delayed, so that the sequestra become embedded in dense new bone, a cavity may be left which will require a plastic operation for its closure. In milder infections, portions of the bone fragments become temporarily devitalized, but subsequently are revascularized by invasion of new blood-vessels and tissue cells derived from the adjacent bone.

Conditions associated with rapid or with slow repair.

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place; for example, the ends near the shoulder, the wrist, and the knee. Repair is delayed or prevented by old age and atrophy, debility, want of apposition between the fragments, *interposition of periosteum, fascia, or muscle* between the broken bone-ends, and, above all, septic infection.

The effect of mobility on repair.—The effect of mobility on repair will depend upon the amount of mobility and the character of the

surrounding

it of mobility

of the ribs.

Similarly, movements of the muscles surrounding the fracture, *if these can occur without causing displacement*, will favour rapid and firm union. On the other hand, movements that cause shifting of the fragments will hinder union; if allowed to continue constantly they will produce permanent non-

union with a pseudo-arthrosis or false joint. This is one cause of non-union, not infrequently seen in fractures of the shaft of the humerus.

General principles of treatment.—The faulty anatomical relations, as demonstrated by X-ray examination, and the bad functional results, so often seen after the older, classical methods of reposition and fixation, have led to reconsideration of the principles of treatment and to a reclassification of fractures depending on their amenability or their resistance to the older "simple" methods.

The *classical treatment* by "setting" and splinting universally obtained until recently and is still largely used. The bone was first temporarily splinted, to prevent further injury, by binding the arm to the trunk, or the leg to its fellow or to some convenient rigid bar such as a stick; then, at leisure, the bone was "set" by manipulation with the intention of adjusting the fragments in exact apposition, but radiography has shown that rarely is this object accurately attained. Finally, a splint was applied to fix the broken bone, together with the joint above and that below the fracture. This splinting could only be efficacious if the reposition had been adequately secured, and if the tonic contractions of the muscles were neutralized; it was continued for three to six weeks, while union took place. Then the splints were removed and the limb was gradually restored to use by the natural activity of the patient, somewhat protected, in the case of the lower limb, by the use of crutches

Undoubtedly, in many cases sufficient success was attained by these methods. But radiography has increased the responsibility of the surgeon and raised the standard of result demanded by the patient.

The criticisms of the old method, as seen in its crudest form, are that very frequently external manipulation could not secure exact reposition of the fragments, that bandaging a limb to a splint did not prevent muscular contractions and the consequent overlapping of the bone-ends, and that fixation of the whole limb caused an unnecessary degree of muscular adhesion and joint fixation

Application of this method to an incomplete fracture, especially one near a joint, may secure restoration of shape, but causes unnecessary joint and tendon stiffness, and perhaps prolonged crippling. The fixation of a clavicular fracture, a Colles's fracture of the wrist, or a Pott's fracture of the ankle, for four weeks may produce more disability than would result from entire neglect of the injury. In a complete fracture with wide separation of fragments this method often only perpetuates and increases the original deformity.

Three modifications of the old system of treatment have materially improved its efficiency; they are—(1) the setting of the fracture under direct inspection through the radioscopic fluorescent screen or under the check of repeated radiograms; (2) the replacement of flat wooden

waned among surgeons. Twenty-five years ago regarded as an act of almost criminal daring, it was recognized by many surgeons a few years later as the routine method for all adult cases treated in hospital. The experience of the war has brought it again into general disfavour, and it is now necessary therefore to restate the indications for its use. An efficient operation for the union of a fracture implies that the bone fragments shall be united so firmly that disunion cannot take place before natural repair has occurred. There are four principal methods by which such an operation is carried out:

Plates and screws.—Arbuthnot Lane, the great advocate of the operative treatment of fractures, introduced the method of screwing long thin steel plates on to the outer surface of the bone by short screws, which penetrated only one side of the tubular bones. This method has achieved such a vogue that it is regarded by many as the only method of operative treatment. It is best suited to slightly *oblique fractures of the shafts without serious comminution.* It requires that the bone be widely exposed for some distance above and below the fracture. The accurate application of the plate in a case with much displacement may be a matter of difficulty. After the operation the limb must be efficiently supported by a good splint, or plaster of paris, for a lengthy period, because if any strain is put on the bone before callus union has occurred, the screws become loosened and the fracture is displaced.

Encirclement by wires or bands.—In very oblique fractures of the shafts of the long bones the simplest and most efficient operative treatment consists in first accurately replacing the fracture, *clamping it in position, and then surrounding both fragments* with two double loops of strong wire, or with two special steel bands known as Parham's bands

Intramedullary pegs.—*In the case of a transverse fracture* of the shaft a very simple method of union consists in placing a peg made of bone or ivory in the medullary cavity of one fragment and then levering the other fragment so as to engage with the projecting end of the peg. Such a peg, being made of animal material, becomes incorporated into the living bone.

Bone-grafting.—In fractures where there has been some delay in union, a [illegible]
substance, [illegible]
piece of li[illegible]
bedding this graft into the fragments of the bone to be mended. The graft may be used as an intramedullary peg, or may be inlaid into grooves cut in the cortex of the fragments and exactly shaped for its reception.

These four are the main methods of operation, but there are, of

course, other methods, such as nailing detached fragments on to the main shaft of the bone, or the use of through-and-through bolts secured by nuts, which are indicated in special cases.

There is still considerable difference of opinion as to the type of fracture in which open operation should be the method of choice. First, all fractures in which natural union has failed to occur and in which, owing to the existence of a gap or the wide separation of fragments or the interposition of soft parts, natural union is unlikely, require this treatment. Secondly, those cases where efficient traction methods have failed to reduce the displacement may require it, but this indication will depend very largely upon the skill and experience of the surgeon in the use of traction appliances. Thirdly, in certain fractures of the shaft of the femur, or of both bones of the forearm, and in all complete fractures of the patella and olecranon, it may be safely predicted that a well-executed operation will give a more rapid recovery and more perfect function than any other method. This last indication applies particularly to the case of muscular adults.

After-treatment of fractures.—If it has been possible to treat the fracture by some method which permits massage of the muscles and movements of the joints while the callus is forming, then there is not the same sharp demarcation between treatment and after-treatment that occurs in cases which have been rigidly fixed for a long period. But if after-treatment is defined as treatment of the limb during the first period of its active use, then three measures should be adopted. (1) The various resources of physico-therapy should be used, such as massage, passive movements of the joints, active exercises against resistance and, in exceptional cases, electrical treatment and hydrotherapy; but it should be noted that the necessity for all this treatment indicates some shortcoming in the primary treatment of the fracture (2) Active voluntary exercises are the most useful as well as the most natural method of restoring function, and should always be directed towards re-education in those movements which are most readily lost by disuse, such as abduction of the shoulder, supination of the hand, abduction of the hip, flexion and extension of the knee, dorsiflexion and inversion of the foot. (3) The tendency of special fractures to late deformity when subjected to weight-bearing should be borne in mind, and prevented by suitable appliances such as the walking calliper splint for fractures of the femur and the outward tilting of the boot after Pott's fracture.

Complications which arise during and after treatment.—In addition to the complications of a fracture due to the coincident injury of other structures than the bone, such as rupture of an artery, division of a nerve, or dislocation of a joint, certain complications may occur during or after treatment.

Gangrene.—This may be due *to primary injury of the blood-vessels*, or to pre-existing disease such as endarteritis In such a case the symptoms will develop early, and amputation must be carried out rather in relation to the vascular lesion than to the site of the fracture. Or gangrene may be caused by the tight bandaging of the limb to a splint, by acute flexion of a limb after bandaging, or by the swelling of a limb after the bandage has been applied, particularly when plaster of paris has been used. The treatment of such conditions consists in the immediate release of the constricting bandage, with treatment appropriate to the impediment of circulation, such as elevation of the limb, with light traction applied to bring the fracture into alinement. Gangrene may also be caused by acute infection in an open fracture, and is then frequently associated with gas-forming bacteria.

Ischæmic contracture is brought about by tight bandaging, just as gangrene may be, but the constriction is usually of a less degree. It is most commonly seen in the forearm, and more rarely in the leg below the knee. It is due to a temporary anæmia of the muscles and nerves of the part. The affected muscles lose their structure and function, and become converted into fibrous tissue which gradually undergoes contractive shortening Various trophic and sensory changes are associated with this paralytic contracture.

Myositis ossificans.—In this condition, bone-formation of an irregular kind spreads from the site of fracture into an overlying muscle, so stiffening it and limiting movement. This complication, which is a rare one, only occurs at the lower end of the humerus, invading the brachialis anticus, or in the front of the femur, affecting the crureus. The exact causation is obscure, but the condition is particularly liable to occur in association with incomplete fractures when ill-judged and excessive massage and forcible movements have been carried out. *Treatment consists in rest until the formation of new bone has come to an end.* At a later date, when callus-formation has ceased, isolated plaques and spicules of bone may be removed from the muscle and a layer of fascia placed between the muscle and the underlying bone.

Stiff joints.—In all except the most trivial fractures, or those which have been treated in the most perfect manner by early massage and movements, a certain amount of stiffness of the joint usually follows. But this should not be of a greater degree than will pass off in a few weeks of natural use. Economically, articular stiffness may be a serious matter and may greatly prolong a man's incapacity for work.

The stiffness may be due either to intra-articular or to extra-articular causes. In *extra-articular conditions* the muscles, tendons, and ligaments become tied to the bone and to one another by plastic

material; for example, in a Colles's fracture, if the hand and wrist have been fixed on splints for several weeks the extensor tendons of the fingers become adherent to their sheaths at the back of the wrist and thus fix both the joint and the digits. Again, in fractures of the lower part of the femur, especially if infected and open, the quadriceps muscle, if allowed, becomes tied down to the front of the bone, flexion of the knee is difficult, and restoration of function becomes a most tedious and painful affair. The important point in relation to such stiff joints is their prevention by early movements. *Intra-articular adhesions* may result from involvement of the joint surfaces by the fracture, from infective arthritis associated with open fractures, or from osteo-arthritis caused or increased by a fracture near a joint in an elderly subject Severe degrees of intra-articular fixation usually cause permanent disability. If the joint is in good position, it may be wise to permit ankylosis, if it is fixed in a bad position, excision may be necessary.

Malunion of fractures.—It is perhaps exceptional for complete fractures of the long bones to heal so perfectly that no deformity can subsequently be recognized by radioscopy. But the term malunion, as ordinarily applied, means gross deformity of the bone of such a nature as to cause serious loss of function. Assuming that union is firm, there are three elements of deformity which constitute serious malunion, namely, shortening, angulation, and rotation.

1. Shortening is only of importance when it affects the bones of the lower limbs and is of a serious degree. Shortening from an inch to an inch and a half in a young patient can be so readily compensated by a tilting of the pelvis and raising of the heel of the boot that it is quite consistent with perfect walking. This amount of shortening cannot be regarded as a good result, but it can be remedied by other means than operation Any shortening of the leg bones more than two inches in extent constitutes a serious deformity, and results in a limp which can never be disguised. The treatment of such malunion will consist in the first place in raising the heel of the boot and educating the patient to tilt the pelvis, and in most cases this is the end of the matter. Radical treatment consists in lengthening the broken bone or in shortening the good leg It is probably never wise to attempt to lengthen a shortened bone in which repair by ossification is complete. Any case in which union is only by callus and the overlapping fragments still retain their structure should be broken down and treated either by some efficient traction method or by open operation. After final repair is complete and all the soft parts have adapted themselves to the shortened condition, it is far safer and easier to shorten the corresponding bone of the good leg by a Z-shaped osteotomy. The above remarks apply to conditions of shortening by overlapping of the bone-ends, or by loss of substance without an alteration in the axis of the bone.

skin or mucous membrane which forms the distinguishing characteristic of this type of fracture may be caused by a sharp fragment of bone being driven outwards through the skin. More frequently it is caused by a blunt agent such as a cart-wheel or the explosion of a shell, or it may be due to the small entrance or exit wound of a bullet. The resulting wound and fracture may show every degree of severity. On the one hand, the wound may be clean and heal by first intention, while the fracture runs a normal course. On the other hand, the bone may be reduced to a multitude of splinters, many of which are driven far into the tissues, and some of which are blown out from the limb altogether. The soft parts may suffer any degree of laceration, and, most important of all, dirt, pieces of clothing, and infective material may be deeply embedded in the tissue. The course taken by a case of open fracture will depend very largely upon the manner in which the infected wound has been treated and the correct immobilization of the limb Where infection has been overwhelming or has not been combated in time, septicæmia, gas gangrene, or phlegmonous inflammation of the whole limb may ensue. In such a case the infection may cause death directly, or the fatal issue may be due to ulceration into the blood-vessels and secondary hæmorrhage. In the less fulminating type of case, infection may be virulent but localized to the actual seat of injury. Sloughing and suppuration play havoc with the soft parts, whilst a considerable portion of the bone becomes necrosed, this being particularly the case with those fragments which have lost their vascular supply wholly or in part.

Such a condition will never make any progress to recovery until the tissues have been freely drained and all gross dirt and dead bone removed. Then, however, repair of the fracture takes place, and eventually a large mass of callus is formed, in the interior of which stray bits of dead bone may be embedded; from the cavities containing such sequestra more or less tortuous sinuses may lead through the callus and soft parts to the exterior.

The treatment of compound fractures must be considered in four stages.

During the *first stage*, within twelve hours of the wound, energetic attempts should be made to sterilize the wound. The ragged skin edges are to be cut away, the torn tissues freely exposed right down to the fracture, and all dirty, torn, or ragged tissues removed or trimmed up. Bits of bone which are certainly bereft of their connexion with soft parts should be removed, but all bone fragments in which there is any possibility of an intact blood supply should be preserved with the utmost care. The wide removal of all the fragments of a fracture so as to take away the whole thickness of the shaft of the bone, if done in this early stage, will certainly lead to non-union. The wound is to be

sutured in layers. In the comparatively clean *open fractures of civil* life the question will arise, at this early stage, whether the exposed bone should be fixed by plates and screws or other internal fixation device. This plan has often succeeded, but it has probably more often failed, and it is far wiser at this stage to be content with cleansing the wound and suturing it with a few interrupted stitches. If infection has been thus eliminated, the wound will heal by first intention, and an open operation, if required, can be done later with greater safety.

Second stage.—After the lapse of 12–16 hours from the infliction of the wound it is seldom possible to sterilize and suture it. The wound must then be drained or packed with such antiseptics as B.I.P.P. or flavine. By some form of traction the comminuted bone should be kept in good alinement and at full length. If the wound has been properly treated and well drained, healing of the fracture will take place in a period not much longer than that required by a closed fracture; if not, union may occupy several months, and then only be weak and soft.

Third stage.—After firm bony union has taken place, one or more septic sinuses may persist, these being generally caused by the inclusion of sequestra in deep cavities of the new bone. Such a condition will usually continue indefinitely unless actively treated. Treatment should be undertaken as soon as possible, because the persistence of chronic suppuration undermines the patient's health and leads to scarring and mutilation of the tissues of the limb; it consists in exposure of the bone, free opening up of the sinuses, removal of sequestra, chiselling away the walls of the cavity, and obliteration of this cavity by turning into it a flap cut from an adjacent muscle.

Fourth stage.—In those cases where, owing to the primary destruction of the bone or to injudicious removal of loose fragments, a gap has been left, this will have to be made good in one of two ways. When, as in the humerus, some shortening is unimportant, the ends of the bone must be refreshed, shaped by a step-cut operation, and then fixed together. When it is necessary to preserve the full length of the bone the gap must be filled by means of a bone-graft.

Ununited fractures.—The causes of non-union are the following:—

1. *Mechanical.*—Of these the most important are the loss of substance brought about by primary injury, or by excessive removal of comminuted fragments, and the interposition of soft parts, so liable to occur if the fragments are widely separated. Two less frequent mechanical causes are excessive mobility, particularly in the case of a single bone such as the humerus, and traction on the fragments, such as is common in the patella or olecranon, and much rarer in the humerus when excessive traction has been used. Loss of substance will not

necessarily cause non-union unless the affected bone be one of a pair, such as the radius and ulna or the tibia and fibula, when the companion bone prevents the fragments being drawn together.

2. *Inflammatory.*—Sepsis associated with a fracture does not usually lead to non-union. Healing may be delayed, but eventually becomes firm with considerable excess of callus. But, exceptionally, sepsis may cause non-union, either by inducing necrosis of the ends of the main fragments or of a number of small fragments, or in cases of chronic suppuration by producing sclerosis of the bone-ends before callus union has taken place.

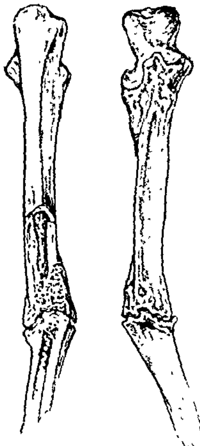


Fig. 825.—Fibrous union of ulna. (Museum of Royal College of Surgeons.)

3. *Diseased conditions* are comparatively rare causes of non-union. They are, cysts of the bone, particularly the so-called fibro-cystic disease, tumours of bone, either sarcoma or carcinoma, and chronic infective disease, either *gummatous* or tuberculous.

Certain general diseases, e.g. syphilis and rickets, are often cited as causes of delay or non-union of fractures, but this is very much to be doubted. Local gummata may, however, be the cause of spontaneous fracture or of non-union.

Anatomical varieties of ununited fractures. 1. *Delayed union.*—The bones are healthy, but want of apposition, the interposition of soft parts, or infection has prevented the formation of a callus bridge between the fragments. Provided that such conditions are remedied within a few weeks of the injury, spontaneous union will then probably occur.

2 *Non-union.*—The bones have undergone certain changes, as the result of which natural union is impossible. These changes may be in the nature of sclerosis or of atrophy, the former being present when the bone-ends are in approximate contact, and the latter when they are separated by a considerable gap. A condition of *fibrous union* is one where the bone-fragments are thickened and closely tied to one

Secondly, in all cases where it is justifiable to shorten the bone, the bone-ends are fitted and fixed to one another, either by breaking up one bone-fragment and impacting the other into it, or by a more exact shaping of the bone-ends by a step-cut operation (Fig. 827), or by

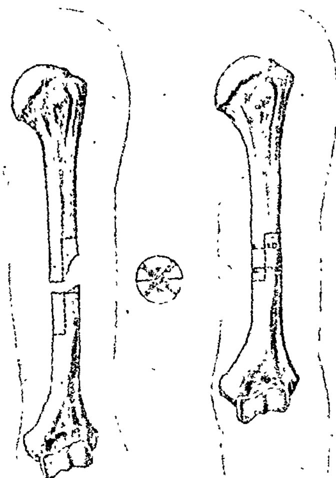


Fig. 827.—Diagram of step-cut operation for ununited humerus.

shaping one end as a peg while the other is hollowed to receive it. Thirdly, if there is a gap which cannot be obliterated by bringing the bone-fragments together, this gap must be filled by means of a bone-graft. Such a graft must be taken from the patient's own tissues, usually from the crest of the tibia. It is fixed into the gap by various devices of joinery. Thus, it may be shaped like a cricket-ball (Fig 828),

the two small ends of which are thrust into the marrow cavities of the fragments, while the thick middle part fills the gap; or it

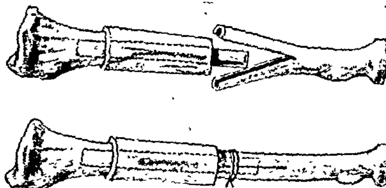


Fig. 828.—"Cricket-bail" graft for gap fracture of radius.

may be inlaid into a *groove cut in the cortex of both fragments* (Fig 829); or *it* may be thrust into one fragment and inlaid on to the other.

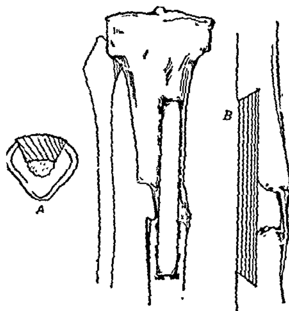


Fig. 829.—Inlay bone-graft for gap fracture of tibia.

A, Section B, Side elevation of the graft.

After any of these operative procedures the limb must be *firmly* immobilized, usually in plaster of paris, for a period of two or three months. A protective case splint made of leather must then be provided, and worn for at least a year.

SPECIAL FRACTURES

NASAL BONES

Fractures of these bones have been discussed earlier in this volume (*see* p. 211).

THE SUPERIOR MAXILLARY BONES

Fractures, generally caused by a fall on the face, may involve one or both of these bones. They are irregular, the alveolar process being separated, the *front wall of the antrum* driven in, or the whole bone smashed

or separated from its attachments; in the latter case the malar bones may retain their normal position. The superior maxillary bone is freely movable, but there is little deformity. Fractures of the anterior wall of the antrum may be associated with displacement of the malar bone, which is forcibly driven down and impacted into the maxillary bone. The signs and symptoms will vary with the type of fracture. The skin of the face or the mucous membrane is often torn and lacerated. If the alveolar process be fractured there may be considerable depression of the face. The fragments may be movable, with crepitus. When the malar bone is driven down, the whole side of the face may be flattened. The infra-orbital nerve may occasionally be implicated.

Treatment.—If the whole bone be completely detached with but little deformity, it is only necessary to immobilize the fragments. The wounds are carefully cleansed and sutured; the movable portion of the face is fixed by bands of adhesive strapping; the mouth and nose must be kept carefully cleansed. At first the diet must be a fluid one, to prevent pressure on the movable parts. Union is usually firm at the end of four to six weeks. If there be much displacement, attempts must be made to replace the fragments. This may be done by external manipulation, or, if there be a wound, use may be made of this to introduce a pair of forceps and thereby replace the separated portions. With displacements of the alveolus it may be necessary to bind the jaws firmly together so that the lower one acts as a splint to hold the fragment in place.

THE MALAR BONE

Fractures of the malar bone are unusual. They are caused by heavy blows, the bone being displaced as a whole; it is generally driven downwards and inwards, and may interfere with the coronoid process and so limit the movements of the lower jaw. There will be much pain and bruising and, if the bone be displaced, a marked depression to the outer side of and below the eye.

Treatment.—Attempts should be made while the injury is recent to replace the bone by pressure and manipulation, preferably under general anæsthesia. If this fail a small incision may be made above, and a blunt hook inserted and passed over the lower end of the bone; with the aid of this the bone may be pulled back into its normal position. There is little or no tendency to recurrence.

THE HYOID BONE

This bone is occasionally fractured in attempts at throttling or at suicide by hanging. The front of the neck is painful, swollen and bruised, and occasionally œdema of the larynx may lead to a respiratory obstruction. There is generally little or no displacement, and if the parts are kept at rest good union will take place.

THE INFERIOR MAXILLARY BONE

Fractures of the inferior maxillary bone are common and are generally due to direct violence. According to the site of the fracture, four different varieties are described:

1 **The canine fossa.**—This is the most frequent site, for in this position the bone is weakest. The fracture may be unilateral or bilateral, the latter showing the greater deformity. The cause is a

blow on the tip of the chin, or occasionally on the side of the chin. The muco-periosteum lining the inner aspect of the bone is practically always torn, *so that a compound fracture results, and sepsis* from the oral cavity is very likely to take place. Signs of local trauma are marked, and there are pain and tenderness on biting or pressure. *The line of the teeth is altered, the anterior fragment* being pulled downwards and backwards by the attached muscles, a deformity which is more marked in bilateral cases. Crepitus may be present. If sepsis occur, necrosis of small fragments of the bone is very prone to take place.

Treatment.—These cases should always be treated in conjunction with a dentist, the best results being obtained by the application of a specially fitted plate cemented over the teeth. The plate fits *as a cap over the whole row of teeth in the lower jaw, the teeth being* embedded in the cement while it is still soft, so that the two fragments are readily fixed in accurate position. When such a plate is *applied the patient can safely eat soft foods, the mouth can be freely* opened without disturbing the fragments, and its cavity thus frequently and thoroughly cleansed. At the end of three weeks the plate can easily be removed.

If there is a difficulty in reducing the deformity, or in holding it by this method owing to few or bad teeth, a combination of inside and outside splints should be used. The former is moulded over the teeth or gums, the latter is moulded on the lower surface of the jaw, and *the two splints are fixed together by metal bars* which emerge from the angle of the mouth.

If a portion of the body of the jaw has been lost by sepsis or trauma, *a bone-graft operation should be done. A period of several months* must elapse in order to allow the mouth wound to heal firmly, and during this time the position of the jaw should be maintained, if possible, by *an interdental splint fixed to the teeth on each side of the gap.*

The fracture is exposed by an incision below the jaw, and the ends are cut off square A piece of the crest of the ilium is taken and cut to fit the gap tightly. The graft may be fixed in place by tendon or wire sutures.

2. **The angle.**—This variety of fracture is much less common than the first. It is generally caused by direct violence at the angle of the bone. This portion of the bone being in its greater extent covered by the internal pterygoid and masseter muscles, a fracture here is not usually compound. Occasionally, however, it may reach forward anteriorly to the alveolar margin, and will in this case *communicate* with the cavity of the mouth. The symptoms are very ill defined. Owing to the attachments of the internal pterygoid and masseter muscles, there is *generally* no displacement. There will,

however, be signs of local trauma, and deep tenderness on pressure or on attempting to bite. Crepitus may be obtained by gripping the anterior portion between the finger and thumb and moving it over the posterior portion.

Treatment.—If there be no communication with the mouth and but little separation, it is only necessary to prevent the patient from biting until bony union takes place. This will generally require the application of a four-tailed bandage. If the fracture be compound, careful oral antiseptic treatment must be instituted.

3. **The coronoid process.**—Fracture through this process is very uncommon. It may be caused by direct violence when the mouth is wide open, or occur in association with fracture of the zygoma. There is usually but slight displacement, owing to the wide attachment to the temporal muscle on the inner side of the bone. If, however, this attachment be torn, the separated fragment will be pulled up into the temporal fossa. If there be no displacement, movements of the jaw will be weakened and painful, while with complete separation movements or forcible closing will be accompanied by bulging of the temporal muscle, and the separated fragment may be felt.

Treatment.—In fracture without displacement the jaw should be supported and the patient fed on soft food. If the fragment be separated it should be cut down upon, drawn into position, and fixed there with a small suture of silver wire.

4. **The condyle.**—This variety of fracture also is very rare. It is caused by direct violence or by blows on the jaw. Either the neck of the bone may be fractured or the condyle itself splintered. There is no displacement, but movements are limited and a grating sensation may [illegible]

Treat[illegible] losis [illegible] may [illegible] it w[illegible] better to remove [illegible] ion, but if the condyle be fractured it [illegible] to remove it entirely, to round off as far as possible the main portion of the bone, and to turn a small portion of capsule or aponeurosis into the joint to prevent bony union.

THE STERNUM

Fractures of this bone are very rare, and are usually due to extreme violence, when the sternum may be driven inwards, as a part or as a whole. In severe smashes the patient may be doubled up so that the spine and the sternum are both fractured. If the body is forcibly bent the sternum alone may be fractured, possibly owing to the chin being driven on to it. In the majority of cases there is either an associated fracture of the ribs or clavicle, or the condition is accompanied by injuries of the thoracic viscera. If the fracture be simple, the lesion is usually transverse, the upper fragment being displaced backwards.

Treatment.—If the fracture be associated with severe injuries of the viscera, little can be done for it, but if it be uncomplicated the usual deformity of backward displacement of the upper fragment can be rectified by forcibly extending the trunk. If this fail, open operation should be performed'

THE RIBS

These bones are very frequently fractured. The lesion is more common in elderly people with brittle bones, and in such patients the ossifying costal cartilages may be broken instead of the bone. The 4th to the 7th ribs, being the most prominent, are those most commonly affected. There are two main types of fracture: (1) Those due to *direct violence:* here the violence is localized to a small area, and *the damage occurs at the site of the injury; the fragments are driven* directly inwards, and may injure the pleura or lung. (2) Those due to *indirect violence:* these are the more common. The chest as a whole is crushed, usually antero-posteriorly; several ribs may thus be broken. The fracture generally occurs at the angle of the rib, for this is the point of greatest curvature. The fragments are driven outwards, and thus there is less liability to injury of the underlying structures.

The patient will complain of severe localized pain, much increased by movements and by deep inspiration; crepitus may be felt, or heard with the stethoscope, on pressing the chest antero-posteriorly, a movement which causes pain localized to the site of the injury; if the pleura be injured, there may be evidence of hæmothorax; whilst if the lung be affected, hæmoptysis, pneumothorax, or surgical emphysema *may be present. If the fracture be due to direct violence there* will be signs of local trauma.

Treatment.—In the slighter cases the whole of the affected side of the chest must be fixed by a careful application of adhesive strapping, the chest being fixed while it is in the position of full expiration, and the strapping crossing beyond the middle line both *in front* and behind. If there be any intrathoracic complication the patient must be kept at absolute rest in bed, though *not in the completely* recumbent position. Aged patients should be given stimulant expectorants, strychnine, and, if necessary, cardiac stimulants. Here *again it is usually preferable to strap the chest,* a method of treatment which is not generally advocated from the apprehension that the fragments may be driven yet farther into the *lung.* It generally, however, gives distinct relief, and the danger is greatly overestimated. If there be rapidly increasing pneumothorax or hæmothorax, operation on the injured lung will be required.

THE CLAVICLE

This is more *frequently fractured* than any other bone in the body. The injury is most commonly caused by falls upon the out-



Fig 1.—Fracture at junction of outer and middle thirds of clavicle



Fig. 2.—Impacted high fracture of surgical neck of humerus.



Fig. 3.—Fracture of shaft of humerus above insertion of deltoid.

(*From Ironside Bruce's "Fractures and Separated Epiphyses"*)

PLATE 135

stretched hand, for here the whole weight of the body is transmitted to the arm through the clavicle, which forms the weakest spot in the line of bone extending from the wrist to the sternum. In such cases the tendency to fracture is increased by the curves of the bone Direct violence may, however, give rise to fractures in any part of the bone. Three varieties of fracture may be considered:

1. **The shaft** (Plate 135, Fig. 1).—This is much the commonest position, the fracture taking place at the junction of the two curves; that is, about the middle of the length of the bone. It is generally due to indirect violence and to falls on the hand. The line of fracture is usually oblique, and may pass from behind either inwards or outwards. The lesion is common in young children, and is then often of the "green-stick" variety. The deformity is very characteristic. The inner fragment, bound down by the rhomboid ligament, undergoes little or no alteration in position, but the outer fragment shows threefold displacement. Its outer end is markedly displaced downwards by the weight of the arm; it is drawn inwards by the muscular contraction and overlaps the inner fragment; lastly, its outward extremity is tilted forwards owing to the fact that the scapula tends to embrace the side of the thorax. The relative degrees of these deformities differ in individual cases, and the treatment will vary according to the predominant displacement. The patient suffers from pain and limitation of movement of the shoulder, and walks supporting the affected arm in the opposite hand. The deformity is well marked, the irregularity in the line of fracture readily felt, and abnormal mobility easily manifest

Treatment.—Many methods of treatment have been employed, but no one method has been found applicable to all cases owing to the fact that the predominant deformity is not always the same. The most useful method for the more common displacement, i.e. when the tip of the shoulder comes forward, is that described by Sayre. A strip of adhesive strapping is fixed round the arm just below the axilla, the arm pulled backwards, and the strap wound round the back of the chest, to which it is made to adhere. A second strip has a small hole cut in it to receive the tip of the elbow The hand of the affected side is placed on the chest just below the opposite shoulder, the tip of the elbow pulled forwards as far as possible, the strapping placed on the outside of the arm and continued on to the unaffected shoulder. The other end of the strap is passed over the back on to the same shoulder and fixed there. By this means the elbow is pulled as far forwards as possible and fixed in position. Therefore, with the upper strap acting as a fulcrum, the tip of the shoulder is pulled backwards. Before applying the strap the skin should be freely dusted with boric acid, and the opposing

surfaces of the skin separated by strips of gamgee tissue. If the deformity be mainly one of overlapping, a big pad of tissue should be placed in the axilla before the application of the strapping. When the elbow is drawn to the side, the shoulder is then levered out over the tissue. This apparatus should be changed every week, and entirely removed at the end of three weeks. The arm is then worn in a sling for a further week. When Sayre's method fails, success is sometimes secured by the "knotted handkerchief" device. A large handkerchief is looped round each shoulder and tied behind. The tails are then fastened together behind the back

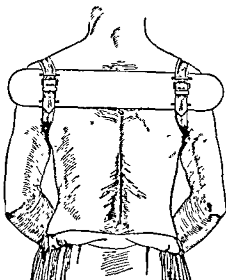


Fig. 830.—Back splint for fractured clavicle.

By this means forward displacement is corrected if it be the most prominent feature. Padded loops of domette bandage, stitched behind instead of knotted, are preferable to the handkerchiefs. The same principle may be carried out more accurately by use of a simple splint across the back to which both shoulders are strapped (Fig. 830), the arm of the affected side being supported in a sling If carefully carried out the methods first described will very seldom fail In some rare cases, especially if complicated with fractures of the upper ribs, it is advised that the patient be kept in bed on his back, with a pillow or sand-bag between the shoulders.

2. **The acromial end.**—This fracture may be caused by direct violence or indirectly by falls upon the outstretched hand. It is a great deal less common than fracture of the shaft. Two types are described: (a) *Between the coronoid and trapezoid ligaments.* The fracture here is usually transverse, but, since both fragments are firmly fixed by the above ligaments to the coracoid process no deformity results. There is local tenderness, bruising and swelling, and the fracture is made manifest by a radiograph. The arm should be kept in a sling for three weeks, movements of the shoulder-joint being begun at the end of a week. (b) *Outside the trapezoid ligament.* In this form the outer fragment, together with the arm, may drop vertically downwards, but this can only take place if the coracoid process of the scapula be allowed to fall away from the inner fragment, that is, if the coronoid and trapezoid ligaments are ruptured.

In other cases there will be no deformity, the fracture being only discovered by means of a radiograph.

3. **The sternal end.**—These fractures may be due to direct violence or to blows above the tip of the shoulder, the lesion in the latter case replacing a dislocation of the sternal end. Displacement is slight unless the rhomboid ligament is torn. Reposition can usually be best brought about by the application of a large axillary pad, the arm being then levered to the side.

Very rarely the epiphysis of the inner end may be separated, but since this epiphysis only appears at the age of 20, and unites with the shaft at 25, such a lesion is very uncommon.

THE SCAPULA

Fractures of this bone are rare, but are of many different types. They may be due to direct or to indirect violence.

1. **The body.**—Although the body forms in its greater part a delicate and thin plate of bone, yet it is so embedded in muscles that fractures are rare. They are always due to direct violence such as blows or crushes, and are thus in nearly all cases associated with fractures of the underlying ribs. The fracture is generally comminuted or irregularly transverse. In these circumstances there is, owing to the wide attachments of the muscles, little or no displacement In other cases a strip may be torn off, especially from the vertebral border, and if the aponeurosis be also torn there will be considerable displacement. The patient complains of severe localized pain, greatly increased on movement. Bruising and swelling are often present, and a portion of the bone may be found freely movable, the movements giving rise to crepitus. There will probably also be evidence of fracture of the ribs, and perhaps even of intrathoracic injury.

2 **The neck and head.**—These fractures are all rare, and are most commonly caused by blows on the head of the humerus. Three varieties are recognized:

(*a*) The glenoid cavity.—In this form the head of the humerus, being driven against the head of the scapula, breaks off obliquely the lower part of the glenoid cavity At the same time the neck of the humerus is not uncommonly injured. The shoulder is swollen and very painful; movements are limited, and there is evidence of increased fluid in the joint; at times crepitus can be obtained. In the majority of cases a diagnosis is impossible without an X-ray photograph, there being, as a rule, but slight displacement of the fragments

(*b*) The anatomical neck.—The injury is generally similar to that just described, but the line of fracture occurs farther back, so

that the whole glenoid cavity is separated from the body of the bone. The shoulder is somewhat flattened and the arm lengthened, the separated portion being displaced downwards. The flattening *is not* uncommonly, however, overshadowed by the surrounding effusion. Movements are limited, and there may be pain with crepitus. A *diagnosis is usually not made without an X-ray photograph.*

(*c*) **The surgical neck.**—In this case the line of fracture is still farther inwards, the separated portion including the coracoid process. *Occasionally the lower part of the line of fracture* passes through instead of below the glenoid cavity. Like the other

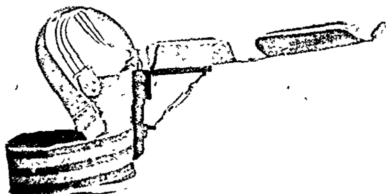


Fig. 831.—Abduction arm-splint with movable elbow.

varieties, it is caused by a blow on the head of the humerus. The shoulder is flattened, the arm lengthened, and crepitus is felt on movement. The arm is not abducted, as in the case of a dislocation.

3. **The acromial process.**—*Fractures of this portion* are rare, but may be caused by direct violence. Either a small portion near the tip may be separated or practically the whole process broken off *close to the spine. In the former case there are* local tenderness and movement of the separated portion, but displacement, owing to the wide attachment of the deltoid muscle, is slight. In the latter case there is also *but little displacement, unless there* is an accompanying fracture of the clavicle. The line of fracture may be felt on palpation of the spine.

4. **The coracoid process.**—*This* may be separated by direct violence, with or without a fracture of the clavicle. As a general

rule there is but little displacement, owing to the firm attachment of the process to the under-surface of the clavicle, but if the trapezoid and conoid ligaments be torn the process is drawn downwards by the coracc-brachialis and short head of the biceps.

Treatment of fractures of the scapula.—As a rule, very little displacement of fragments occurs in these fractures. Therefore no splinting will be necessary. The arm should be supported in a sling, and massage and movements carried out from the commencement. If there is displacement of the neck of the scapula, this should be corrected and the weight of the arm taken by a sling which ties the elbow up to the opposite side of the neck, or, better still, the whole arm should be supported in an abduction splint (Fig. 831).

THE HUMERUS

This bone is very commonly fractured, the lesions being divided into those of the upper extremity, the shaft, and the lower extremity.

1. **The upper extremity.**—Several varieties of fracture occur in this situation:

(*a*) The anatomical neck.—This is not a common fracture. It is more likely to take place in elderly people with a certain amount of rarefaction of the bone, and is nearly always due to direct violence such as blows or falls on the shoulder. The line of fracture is transverse, and not uncommonly impaction takes place, but if this does not occur the upper fragment may show very marked displacement, passing downwards or forwards, or in some cases being rotated. The displacement is more marked if there be an associated dislocation (Plate 135, Fig. 2). Since the anatomical neck lies within the joint cavity, there will always be a certain amount of intra-articular effusion. The patient complains of pain following a blow, and shows swelling and bruising, with considerable limitation of movement. A slight amount of flattening due to the displacement of the bone is usually hidden by swelling of the joint. Attempts at movement cause much pain, and may be accompanied by crepitus. In many cases it may only be possible to distinguish this lesion from osteo-arthritis by means of an X-ray photograph.

(*b*) The surgical neck (Plate 135, Fig. 3).—This fracture is much commoner than the last The fracture is usually transverse, and a spicule of bone often projects upwards from one side of the shaft. The shaft of the bone is drawn upwards and inwards, and may form a distinct swelling in the outer wall of the axilla. A well-marked depression is present on the outer aspect of the arm, but this is one or two inches below the acromion, not immediately beneath it as in dislocation of the shoulder. This fracture may be associated with a dislocation of the shoulder.

A type of fracture similar to the above is produced by separation of the upper epiphysis, which usually occurs at an age between 7 and 20.

(c) Separation of the great tuberosity.—The great tuberosity may be fractured by direct violence, or torn off as a complication of dislocation. If this process be greatly displaced and the case is seen early, open operation is the best treatment; the head of the bone being exposed by an incision along the mesial border of the deltoid, the tuberosity is dragged forward and secured in position by suturing that portion of the capsule which covers the fragment to that attached to the main part of the head of the bone. A further security

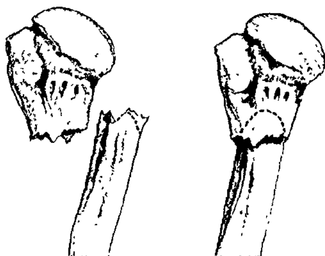


Fig. 832.—Operative impaction of shaft into head of humerus.

may be given by driving a bone-nail through the tuberosity into the head.

Treatment of fractures of the head and the neck of the humerus.—Abduction is the great secret of success in the treatment of all these injuries. Those with little or no displacement should be put up in an abduction splint (Fig. 831) for two weeks, massage and movements being applied from the outset If displacement exists, forcible traction should be made, under an anæsthetic, in a direction at right angles to the body. Both position and traction should then be maintained by the use of a straight Thomas arm-splint, the ring of which is swivelled and fits over the shoulder. The arm is maintained in this position for two or three weeks, and then placed on the abduction splint. If traction fails to reduce displacement, open operation must be done. The fracture is exposed by an anterior incision between the deltoid and pectoral muscles. It may be necessary to divide the tendon of the latter. Plates and screws are particularly

unsuitable for uniting the bone, and are quite unnecessary. It is usually sufficient to impact the distal into the proximal fragment (Fig 832); the former is shaped as a peg, advantage being taken of the spike which is often found running up from one side of the shaft. In separation of the epiphysis, or in fractures resembling it in position, union may be effected by means of a bone-peg which is first driven into the shaft and then made to engage in and forced up into the cancellous tissue of the head.

2. **The shaft of the humerus.**—This fracture may be due to direct or indirect violence, or occasionally to muscular action. It is the commonest form of obstetrical fracture, when it is usually caused by attempts to bring down an extended arm in cases of breech presentation. The shaft of the humerus may be broken at any point between the surgical neck and the condyles, and it is usual to describe it as in the upper, middle, or lower third. In the upper third the injury is situated above the insertion of the deltoid (Plate 135, Fig. 3), the lower fragment being pulled outwards by the deltoid while the upper is drawn inwards by the muscles attached to the bicipital groove. In the middle third the fracture is usually oblique or spiral and may run in the line of the musculo-spiral groove. Torn fibres of the triceps muscle may become interposed between the fractured ends, thus preventing union, and the musculo-spiral nerve is frequently injured. In the lower third, fractures are slightly oblique from before backwards, the lower fragment usually riding up behind the main shaft.

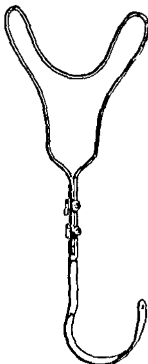


Fig. 833.—Y-extension splint for the humerus. The upper portion is padded and lies in the axilla.

Treatment.—In cases with slight displacement the best results will be obtained by using no splint, the arm being supported by a sling around the wrist, with the elbow flexed, massage and movement being applied from the outset. In cases with marked displacement, traction should be used. If the injury is severe, and especially if it is associated with an open wound, the patient should be kept in bed with weight-extension pulling in the axis of the upper arm, the forearm being suspended vertically. In the great majority of cases, however, he need not remain in bed, but the arm should be placed on a splint which provides continuous traction. Of such splints, the best-known is that of Robert

Jones, but the crutch Y-shaped splint is less cumbersome and quite satisfactory (Fig. 833). Traction straps having been fixed to the arm by means of strapping or glue, the crutch is padded and placed in the axilla, and the extension cord is tied to the end of a C-spring at the lower end of the splint. If the fracture is so low down that the adhesive strapping cannot get a sufficient hold on the distal fragment, the olecranon may be transfixed by a short thin pin (a piece of stout knitting-needle serves very well) and the traction made from the end of this. In all cases the wrist should be slung up to the neck so as to maintain flexion of the elbow. Open operation is indicated if the musculo-spiral nerve has been injured or caught in the fragments, and also in cases of ununited fractures. In recent fractures the bone may be united by a plate and screws or by an intramedullary peg, either of these two methods being suitable for transverse fractures. If the fracture is oblique, it should be joined by two metal bands or wire circles. For old ununited fractures there are two types of operative procedure. In those cases where loss of substance is small and the arm can afford to be shortened, the fragments are each cut in the shape of a step, the two steps made to overlap, and then fixed by bolts or bone-nails. If there has already been much loss of substance and it is desired to retain the fullest length possible of the bone, a bone-graft should be used. A graft is driven into one fragment and inlaid into the other. (Plate 136, Figs. 1, 2.)

3. **The lower end.**—There are three common types of fracture in this position, and several varieties of each. In the supracondylar type (Plate 136, Fig 3) the fracture is more or less transverse from side to side and oblique from behind forwards and downwards, the lower fragment tending to ride up behind the shaft. T- or Y- shaped fractures present an additional vertical line of division running into the elbow-joint; there is usually much effusion into the joint cavity. In the third type of fracture, either the external or the internal condyle is separated from the shaft by an oblique fracture which runs into the joint. In the case of fractures of the inner side of the elbow the internal epicondyle may be broken off without involving the joint cavity. In this last variety there is great liability to injury of the ulnar nerve.

4. **Separation of the lower epiphysis of the humerus.**—The lower epiphysis of the humerus ossifies by four centres, one for each epicondyle and one each for the trochlear and capitellum. At about puberty the external epicondyle, the capitellum, and the trochlea have united, and this centre joins the shaft about the age of 17. The internal epicondyle remains separate until about the eighteenth year. The so-called separation of the epiphysis is usually a fracture of the diaphysis near the epiphysial line. A transverse or T-shaped fracture in childhood may follow the lines of epiphysial cartilage, but the displacement and the treatment are the



Fig 1—Gap fracture of humerus after removal of graft, plates and screws having been applied failure.



Fig. 2—The same case after the use of a two-piece thrust graft; success.



Fig 3—Supracondylar fracture of humerus with backward displacement of lower fragment, before operation

PLATE 136.



Fig 1. — Fractured olecranon, before operation.



Fig 2.—Fractured olecranon, after operation and use of wire suture.



Fig 3.—Colles's fracture.



Fig 4.—Backward displacement of lower epiphysis of radius.



Fig 5.—Fracture of neck of femur.

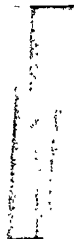


Fig 6.—Fracture of middle shaft of femur.

PLATE 137.

same as in other forms of fracture of this part of the bone. Separation of either of the epicondyles may occur without involving the joint, and this especially applies to the internal epicondyle. But separation of the capitellum or trochlear epiphysis will necessarily be into the elbow-joint.

Treatment.—The treatment of all these fractures in the neighbourhood of the elbow-joint, whether the joint is actually involved or not, requires great care in order to prevent fixation of the elbow, which is very liable to occur from one of three causes—distortion of the bone either by alteration of the line of the joint or by distortion of the articular surface, adhesions in and around the joint and, more rarely, myositis ossificans. In those cases where displacement is not great the treatment should consist in full flexion of the elbow after strong traction of the condyles in the axis of the humerus, the hand being kept in full supination. The chief difficulty in carrying out this procedure occurs in those cases in which a day or more has been allowed to elapse since the accident and considerable swelling has taken place. In such circumstances full flexion is not possible at first, and the arm must be put up with as much flexion as can be achieved without much force, the degree of flexion being increased on the following day. This position of full flexion of the elbow should be maintained for two to three weeks Light massage should be adopted from the outset, and after the first week the elbow should be moved to such degree of extension as can be made without force or pain. There should be only one such movement, the hand being brought down and then up each day. Forcible movements of the pump-handle kind should be most strictly forbidden. They not only cause pain to the patient but, by increasing effusion, limit the mobility of the joint. Cases in which displacement is very marked, or resists manipulative reduction, should be treated by traction upon the elbow-joint, applied by means of a pin through the olecranon or a small clamp attached to the epicondyles. The traction is effected by means of the Y-shaped crutch splint already described, and the elbow should be kept as much flexed as possible.

Operative treatment of fractures of the lower end should be undertaken rarely, the results being usually inferior to those obtained by the methods described above. Conditions which are usually held to require operation may be of three kinds. In the first, there is a supracondylar fracture, the displacement of which cannot be fully reduced, generally because the nature of the displacement was not recognized until some time after the injury; in the second, there are the various comminuted fractures involving the elbow-joint; in the third, there is separation of a condyle or epicondyle. In operating for any of these fractures it is essential that free exposure should be made, the fractured surfaces cleared from clot or soft tissue, and exact restitution made. A lateral

incision will suffice to deal with a separation of one or other condyle. In the case of the inner condyle or epicondyle the ulnar nerve should be carefully exposed as the first step of the operation. In a recent fracture a separated condyle may be fixed to the main part of the bone by a single ivory nail In a case of older date, where movement is restricted by the displaced condyle, it is probably better to remove the latter altogether. In all other fractures of the lower end which require

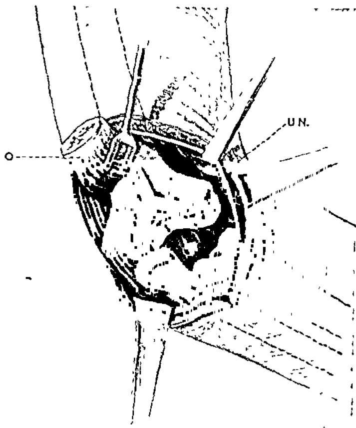


Fig. 834.—Operation for exposure and fixation of fracture of the lower end of the humerus by turning up the olecranon.

O, Olecranon. U N, Ulnar nerve. R, Radius. H, Humerus, with Y-shaped fracture fixed by a plate

operative treatment, adequate exposure requires that the back of the lower end of the bone should be laid bare (Fig. 834) The best way to do this is to make a U-shaped incision over the elbow, the point of the U being below the olecranon. The latter process is divided by a fine saw, and the triceps muscle is turned up. This permits of as complete an exposure as may be required. A transverse fracture of the shaft should be united over a bone-peg. The typical T- or Y-shaped fracture is best treated by an inverted Y-shaped plate, the stem of which fixes the shaft

while the limbs fix the two condyles. The most important detail of such an operation is the accurate fitting together of the fragments before fixing them. On completion of the fixation of the fracture the divided olecranon is replaced and fixed by a wire or tendon suture.

THE ULNA

1. **The olecranon.**—This process may be broken off by direct violence—that is, by falls upon the elbow or by muscular violence such as that used in throwing a weight. In the former case the whole process is usually broken off from the shaft of the bone, whilst in the latter a comparatively small plate of bone is torn off by the triceps insertion. Usually the fracture runs into the elbow-joint, which becomes filled with blood. The olecranon is generally separated for some distance, and also considerably tilted by the action of the triceps muscle. (Plate 137, Figs. 1, 2.)

Treatment should be by open operation, for, although simple massage and mobilization will usually give a very useful arm, the union will be only fibrous, movements of the elbow will be somewhat restricted, and some loss of power will ensue. The fracture should be exposed by an inverted U-shaped incision. The fracture having been exposed, the joint is cleared of blood-clot and the fragment is accurately fitted into position, the elbow being held in almost full extension. Transverse holes are bored through the olecranon and the adjacent part of the shaft. Two fine wire loops are passed through both holes in opposite directions, and these loops are tightened simultaneously, the fragment being firmly held in position all the time The arm is put up in flexion without any splint, and movement of the elbow should be permitted from the third day onwards.

2. **The coronoid process.**—This process may be broken off in posterior dislocations of the elbow-joint. The dislocation should be fully reduced under an anæsthetic, and the arm put up in complete flexion of the elbow and maintained in this position for three weeks after which careful movements may be begun, though the elbow is still kept fully flexed for several weeks longer

3. **The shaft.**—This part of the ulna is generally broken by direct violence—for example, when a blow with a stick is guarded by the uplifted arm. The displacement is usually slight, and the treatment should be by massage and movements, no splint being usually necessary.

4. **The styloid process.**—Fracture of this process is common in association with fractures of the lower end of the radius or in dislocations of the wrist. No special treatment is required beyond that indicated for the major injury.

5. **Ununited and gap fractures.**—These are very uncommon, except as the result of gunshot injuries or, still more rarely,

of osteo-myelitis. As a rule, they cause little or no impairment of function in the arm, and if so they require no treatment. When, however, the fracture occurs near the upper end it will produce some weakness in extension of the elbow. Such a fracture should be treated by the insertion of a graft; when it occurs near the upper end of the ulna the most convenient method is to bore a hole down the shaft of the bone from the tip of the olecranon and to drive a graft, which has been shaped to fit this hole, downwards as a nail, after exposing and refreshing the adjacent surfaces of the fracture.

THE RADIUS

1. **The head and neck.**—The two common types of fracture in this region are longitudinal fissures, which may separate a portion of the circumference of the head, and transverse fractures, separating the head from the shaft. Either of these injuries may be associated with fracture of the outer condyle of the humerus or with dislocation of the head of the radius. They are liable to be followed by functional disability in the form of limitation of movements of the elbow and rotation of the hand, out of all proportion to the anatomical lesion. In cases without gross displacement the arm should be supported with the elbow fully flexed and the hand supinated, whilst daily treatment by gentle massage and movements is carried out from the very first. Complete displacement can only be corrected by open operation. If the upper fragment is large enough the fragments should be united by an intra medullary peg. If the upper fragment is too small, or if a portion of the head is broken off, the small fragment of bone should be removed, the jagged end of the shaft smoothly rounded and rubbed with Horsley's wax.

2. **The shaft.**—Fracture is usually caused by falls upon the outstretched hand, and is a very common injury. The fracture is usually oblique, and not accompanied by much displacement. It is usual to distinguish between fractures above and below the insertion of the [illegible] In [illegible] the biceps and supinator brevis, while the lower fragment is fully [illegible]ted. In fractures below the point named the upper fragment is supposed to lie midway between pronation and supination, owing to the fact that the pronator radii teres to some extent counteracts the supinator muscles. Practically, this distinction is of little importance, because the action of the biceps in causing supination of the upper fragment is so much more powerful than that of the pronator radii teres as to make the action of the latter negligible. The most important factor of displacement is angulation of both fragments towards the ulna, a deformity which is liable to be followed by cross-union, and which, by destroying the bucket-handle

action of the curved radius, will greatly limit the rotatory movement of the forearm.

Treatment.—The fracture should be put up in a position of full supination, the elbow being flexed to a right angle. This position is maintained by a supination splint, which may take the form of an anterior angular, a posterior angular, or a wooden splint consisting of two pieces at right angles to one another, *one piece* lying behind the forearm and the other on the inner side of the upper arm. The wrist and fingers are left free from the bandages, and movements should be practised from the outset. Light massage with movements of the wrist and elbow should be given daily from the end of the first week, but no rotatory movements of the hand should be allowed until the end of three weeks.

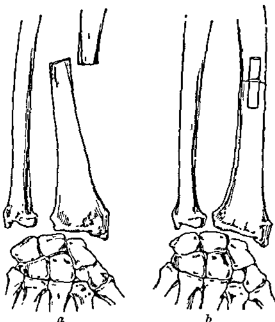


Fig. 835.—(*a*) Typical displacement of a fracture in the middle of the radius. (*b*) Short bone-peg in position.

Complete fractures of the shaft of the radius with overlapping of the fragments, the displacement of which cannot be reduced by manipulations, should be treated by *open operation* Such operation may take the form *of plating or of pegging*. The latter is to be preferred by reason of its simplicity and efficiency (Figs. 835, 836). The fracture is exposed by an anterior incision along the inner margin of the supinator longus. Each fragment in turn is exposed and grasped by a bone-holding forceps, brought up into the wound, and its medullary cavity bored by a twist drill of a size just large enough to bite into the dense bone A short bone-peg corresponding

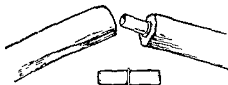


Fig. 836 —Showing how the short bone-peg is inserted.

in size to the drill is taken and driven half-way into one fragment, *the other fragment is angulated outwards (Fig. 836)*, the projecting end of the peg is made to engage in its cavity, and it is then slowly snapped back into position. Whether a plate or a peg be used, great care should be taken to orientate correctly the two fragments so that both may lie in a corresponding position in regard to pronation or supination.

3. The lower extremity.—This portion of the bone is that most often broken, the commonest fracture being known as *Colles's.* In this injury the bone is broken about half an inch above the line of the wrist, the plane of the fracture being obliquely upwards and backwards. It is more frequent in women than in men, and is usually due to a fall upon the outstretched hand while the elbow is flexed and the wrist extended with the hand pronated. The *displacement of the lower fragment involves four constituents; it is* displaced upwards and backwards, rotated backwards round a transverse axis, and rotated towards the radial side of the arm round an antero-posterior axis. The upward and backward displacements are due to the line of direction of the force which produced the fracture, while the rotation towards the radial side is due to the ulnar edge of the fragment being strongly attached to the ulnar bone, while the radial edge is unsupported (Plate 137, Figs, 3, 4). The styloid process of the ulna is usually broken off. As the lower end of the radius carries the hand, there is a displacement of the latter corresponding to the *fracture, that is to say, the hand is displaced backwards and to the* radial side, while the lower end of the ulna forms an undue prominence beneath the skin. The styloid process of the radius, instead of being in its normal position, about half an inch lower than the ulnar styloid, is raised to the same level, or above that of the latter bone. Viewed in profile, the hand and wrist present a curve somewhat similar to that of a dinner fork looked at sideways. The anterior prominence of this curve is due to the lower end of the shaft of the radius, covered by the flexor tendons; *the posterior prominence is formed by the lower* fragment and the wrist-joint.

There are two other fractures of the lower extremity of less common occurrence than Colles's. In *Smith's fracture* the lower fragment is displaced forwards instead of backwards; it is caused by falls upon the back of the flexed and supinated hand. The *chauffeur's fracture* is an oblique fracture of the lower end of the radius by which a triangular portion of bone, including the styloid process, is separated from the main bone.

Treatment.—The treatment of Colles's fracture requires particular care both in the reduction of the deformity and in the preservation of the movements of the wrist and fingers Three conditions of this

fracture must be considered. (1) *Fracture with trivial displacement.* The hand is not displaced backwards or to the radial side to an appreciable extent, and the X-rays show that the shaft of the bone has been impacted into the lower fragment. The treatment consists in light massage and movements from the very first day. The hand may be supported on any form of anterior splint, but Carr's is the most comfortable. It is a flat anterior wooden splint hollowed out at its lower end for the ball of the thumb and having an obliquely-placed round bar, around which the fingers are flexed. It is put on merely as a protection against further injury, and it must be taken off once or twice a day for massage and movements. In addition, the patient should be instructed to open and shut the fingers by his own voluntary efforts as far as this can be done without pain. The splint can be discarded at the end of a fortnight, and soon afterwards light work can be undertaken.

(2) *A recent fracture with marked characteristic displacement.*—Here

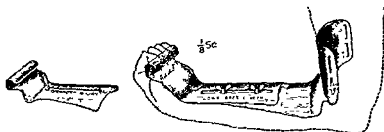


Fig. 837.—Todd's splint.

again, there is often a certain degree of impaction, and this, together with the close attachment of the extensor tendons to the back of the lower fragment, may cause some difficulty in reduction. An anæsthetic should be given, and the lower fragment forcibly brought downwards and forwards and pulled over towards the ulnar side. If there is pronounced impaction, it will best be broken down by an initial movement in the same direction as that of the original violence. If displacement is thoroughly reduced, and particularly if the lower fragment is brought well forward, there will be but little tendency to recurrence, and the case can be treated in the same way as that already described, with the difference that the hand may be allowed to remain on the anterior Carr's splint for a few days before removing the bandages for massage If, however, the displacement tends to recur, this may be prevented either by the use of a posterior as well as an anterior splint, or better still by employing a metal splint such as Todd's (Fig. 837), which keeps the hand and wrist in a position of pronounced anterior flexion.

(3) *An unreduced fracture of several weeks' standing*—The right course to pursue, except in the aged or infirm, is to break down the

fracture by means of forcible manipulation, possibly aided by a Thomas wrench, or after an osteotomy done by a fine chisel inserted between the tendons on the radial and posterior aspect of the fracture.

THE ULNA AND RADIUS

Both bones of the forearm are frequently fractured at the same time. If the violence is indirect we have oblique fractures, that of the radius being in the upper third and that of the ulna in the lower third, while if the violence is direct the bones are broken at the same level. Such injuries involve more displacement than those in which only one bone is broken. There is shortening of the forearm, a certain amount of angulation, and a great tendency for the broken fragments of the two

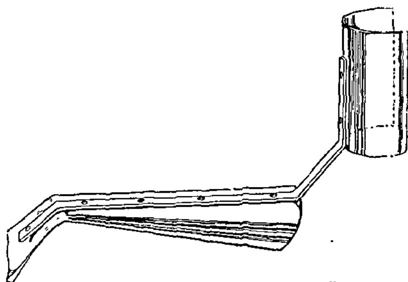


Fig. 838.—Anterior metal supination splint.

bones to fall together towards the mid-axis of the limb. The treatment of these double fractures must chiefly be determined by the amount and degree of displacement. If the bones are in good position, the arm should be put upon a posterior angular or a special supination splint (Fig. 838), so that the fingers can be exercised daily. The splint will, of course, be removed after the first few days for massage and movement, and discontinued altogether after about three weeks. In making movements of the joints concerned, some caution should be exercised in regard to rotation of the hand, it being better to retain a position of full supination until union is firm—that is, for about three or four weeks—before practising movements of pronation.

If the fracture presents much displacement, some appliance should be used which by traction will reduce it, or else an open operation should be done. It is comparatively easy to reduce overlapping and

angulation, either by a weight and pulley in bed, the traction being applied to the hand by a glued-on glove while counterextension is applied to the upper arm,[1] or else by means of some form of wire cradle splint such as that illustrated (Fig. 839). The tendency of the fragments to meet one another in the mid-line of the arm is the most difficult to counteract, and it is probably wise in all young, healthy subjects, even in children, to submit these fractures to open operation, because by this means only can accurate restoration of both bones be brought about. The best method of operation is by means of intramedullary pegs introduced into both bones in the same way as described for the

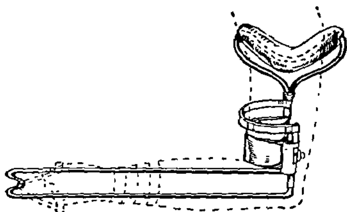


Fig. 839.—Author's wire cradle arm-splint.

radius It will sometimes be sufficient to operate upon the radius alone, as the ulna then naturally falls into a good line.

Cross-union of the radius and ulna is a very unfortunate result of a forearm fracture, because it is very crippling in its effects, and also because it is exceedingly difficult to remedy. For the prevention of this malunion no method is of any use except traction or open operation, as it is quite futile to attempt to separate the radius from the ulna by fitting a narrow splint into the interosseous space. Treatment of the condition requires re-fracture of the radius and an operative restoration of its outward curve. But the results are likely to be disappointing, even though special pains have been taken to interpose muscle between the radius and ulna, and it is wise to put up the hand in a position between supination and pronation, rather more *supinated* than pronated.

BONES OF THE HAND AND FINGERS

Carpus.—The only carpal bone which is commonly fractured is the scaphoid, which is broken by a fall on the wrist. In stokers the fracture may

[1] For the glue method, *see* p. 847.

occur from a sudden check of the shovel. The fracture takes place between the articular surfaces for the trapezoid and radius It is liable to be overlooked and the injury regarded as a mere sprain. If displacement has occurred, reduction may be obtained by alternately flexing and then hyperextending the wrist. If this fails, it is better to excise the broken bone. If there is no displacement the treatment consists in massage and movement, the hand being kept on a "cock-up" splint.

The metacarpals.—These bones are liable to fracture as a result of punching action, when they may be broken at the neck, the middle of the shaft, or towards the base. The oblique fracture of the base of the first metacarpal is often known as *Bennett's fracture.*

The phalanges.—Any of these small bones may be broken, the fractures being the result of direct violence and not presenting marked displacement.

Treatment of fractures of the bones of the thumb and fingers does not, as a rule, present any great difficulty. In cases where there is little displacement, attention must be concentrated upon giving early movements so as to prevent adhesions of the extensor tendons to the bone. In cases with marked displacement the hand should be placed on some kind of ball splint and the fingers flexed over this with s[illegible]
is provided by Verrall's splin[illegible]
that maintains the wrist in [illegible]
strapping is applied, are tied by stout rubber bands to a bar in front of the splint in such a way as to combine traction with flexion.

THE PELVIS

Pelvic fractures may be partial or complete. In the former variety one of the bony processes is broken off; in the latter the ring of the pelvis is broken right through in two points of its circumference.

Partial fractures. — These may involve separation of portions of the spine and crest of the ilium, or of the ischium about the tuberosity, or of the acetabulum. None of these requires any special description; they are associated with localized pain, they are recognized with certainty only by a radiographic examination, and they require no special treatment beyond rest.

Fractures of the **acetabulum** are a more serious problem, as they usually involve a dislocation of the hip. The upper lip may be broken off, and the femur dislocated on to the dorsum ilii. The dislocation may be reduced by the ordinary means, but there will be great difficulty in preventing its recurrence. This may be done either by maintaining the thigh in full abduction for a period of six or eight weeks, or by an open exposure of the fracture followed by fixation of the displaced fragments in correct position by means of bone-nails.

Fractures of the floor of the acetabulum are produced by a violent blow on the trochanter, which drives the head of the bone into the pelvis—the so-called "central dislocation" of the hip. Such a condition requires immediate reduction by powerful traction on the leg under an anæsthetic, followed by continuous weight-extension, applied

preferably by means of a transfixion pin through the lower end of the femur.

Complete fractures of the pelvis are usually due to severe crushes, or to run-over accidents. The ring of the pelvis is broken in front by a fracture through the pubic bones or through the symphysis pubis, and in either case the triangular ligament which runs across the pubic arch is torn, with a consequent rupture of the membranous portion of the urethra. Posteriorly, the pelvic ring is broken through the back of the ilium or by a tearing of the sacro-iliac synchondrosis. The anterior fracture is usually on the opposite side of the body to the posterior fracture Sometimes there is a double anterior fracture and no posterior, the two pubic bones being broken at the junction with their rami and driven backwards towards the cavity of the pelvis. The symptoms of this type of fracture consist of severe shock, great local tenderness, inability to move the legs, and urinary symptoms. Pressing the sides of the pelvis together, forcing them apart, or pressure on the front of the symphysis will cause severe pain. The lower part of the abdomen is rigid, and if some hours have elapsed since the accident there may already be symptoms of extravasation of urine.

Treatment.—The fracture does not present much displacement and requires no special treatment for its adjustment. A firm binder round the thighs and pelvis will afford some relief, and the patient must be kept in bed for a month or six weeks. The main treatment must be directed to the complicating injuries of the bladder or urethra If the patient cannot pass urine there should be no delay in operation. If much shock exists, it is best to be content at first with suprapubic drainage of the bladder, an operation which may be performed under local anæsthesia. When shock has passed off, external urethrotomy should be performed, the urethra being repaired round a rubber catheter passed into the bladder; if there is any difficulty in identifying the proximal end of the urethra, this should be done by passing a sound from above downwards through a suprapubic opening of the bladder. Cases which give some anxiety are those of an intermediate type of severity in which the patient can pass urine but it is deeply blood-stained, and micturition is accompanied by much pain. The question will arise as to catheterization. This should be limited to a single attempt at passing a soft rubber catheter with the utmost gentleness. If the attempt succeeds, the catheter should be tied in place and left for some days. If it fails, the treatment described above must be conducted. In the long run it will usually be much more satisfactory to deal radically with rupture of the urethra at the time than to leave it to a later date when it will be complicated by the occurrence of a severe fibrous stricture.

THE FEMUR

Fractures of the femur constitute a subject of such importance that it will be convenient to describe the different varieties, together with their symptoms and special treatments first, and to reserve for a concluding section a general description and discussion of the routine treatment of these injuries.

1. **The head and neck.**—The angle at which the neck of the femur is set on to the shaft is about 125°, being more open in childhood, and more acute—that is, nearer a right angle—in short, broad adults, particularly of the female sex. The angle also becomes smaller as the result of any softening disease such as rickets; when this change is pronounced enough it constitutes the deformity known as coxa vara. This angle between the neck and shaft is a factor of some significance in the production of fractures; and it is of great importance that the correct angle should be re-established when the fracture is repaired. The portion of the neck adjoining the head is the narrowest and weakest part of the bone, while the base of the neck where it joins the trochanters has a large vertical diameter and is pierced by a number of vascular channels which take blood-vessels from the capsule to the interior of the neck. The anterior surface of the neck of the femur is composed of much thicker bone than the posterior wall. The capsule of the joint, which is very thick and strong in front, is attached anteriorly to the femur along the anterior intertrochanteric line, and from this point of attachment the deep fibres of the capsule, the reflected fibres, run upwards and inwards towards the head for about one-third the distance of the neck; posteriorly the capsule is attached to the neck of the femur about midway between the head and the trochanters.

Fractures of the neck of the femur (Plate 137, Fig 5) may occur at any point between the head and trochanters, and it has been for a long time customary to divide them into intracapsular and extracapsular varieties. But this term is really inaccurate, because so many of the factors concerned involve both intra- and extracapsular parts of the bone. It is better, therefore, to distinguish between high fractures of the neck and fractures at the base of the neck, the one taking place near the narrow part where the neck joins the head, and the other at the wider part where the neck joins the trochanters.

High fractures of the neck.—This variety, which corresponds very closely with the old "intracapsular" variety, usually occurs in elderly patients, especially in women. It is caused by comparatively trivial violence of an indirect character, the patient missing a step, or even merely twisting in bed, or falling a short distance on to the feet. It is very unusual for the fracture to be impacted, but when it is the neck is driven into the head. The symptoms consist of pain over

the hip and inability to stand on the legs; there is little or no swelling or bruising. Shortening is very slight (about ¾ in.), and the leg is only a little everted and adducted. The diagnosis will always be in doubt until the X-ray picture has been seen. There is great natural tendency to non-union; in fact, non-union is the rule unless special methods are adopted to prevent its occurrence. The reason for this is twofold: (1)

of this fracture always presents some difficulty. In elderly feeble patients it is almost impossible to keep them in bed for the prolonged period necessitated by the danger of lung complications, and by their intolerance of any efficient immobilizing apparatus. Such a patient will probably never again enjoy a natural life, and it is better, therefore, to admit this fact at the outset and be content with looking after his general well-being. The legs should be fixed, by sandbags, as wide apart as can be comfortably borne and the patient well propped up. This treatment is continued for a few weeks and then gradually modified, the patient being allowed to sit in a chair or to walk with crutches. In younger and more vigorous patients the choice will lie between fixation of the leg in extreme abduction, by means of a plaster-of-paris case extending from the foot to the chest, for eight weeks, and operative treatment by the introduction of a bone-graft driven into the neck of the femur through the trochanter; both methods give good results. Circumstances suggesting the advisability of operative treatment are the comparative youth and vigour of the patient, and fracture so low down in the neck as to present a good proximal fragment into which the bone-graft can be driven.

Fractures through the base of the neck.—These are usually the result of direct violence caused by falls or blows upon the great trochanter. They occur most typically in labouring men of middle age. There are evidences of local trauma, with much swelling and bruising over the trochanter and in front of the joint. There is well-marked shortening amounting to 1½–2 in. The leg is strongly adducted and fully everted, lying completely on its outer side. This eversion of the leg, which is so constant a feature of fractures of the neck of the femur, is due partly to the weight of the leg rolling it outwards, and partly to the fact that the back of the neck of the femur, being much thinner, is more injured than the front. Comminution and impaction are very commonly present, the neck of the femur being driven like a wedge into the trochanter and splitting the latter into several fragments, the great trochanter, the lesser trochanter, and the shaft being separated from one another. The rich supply of blood in the region of the

fracture provides ample material for repair, and there is therefore no tendency to non-union. *Treatment.*—The typical fracture at the base of the neck with much comminution should be treated by the methods described later as applicable to the femur as a whole. Fractures without comminution are particularly suitable for treatment by the introduction of a bone-peg. Such fractures are somewhat intermediate in position and character between those near the head and those

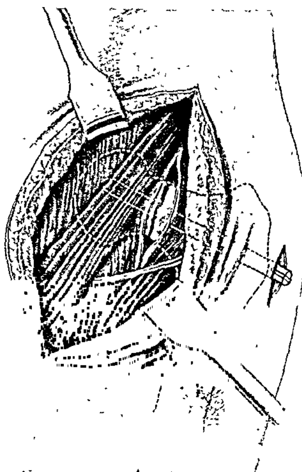


Fig. 840.—Pegging the neck of the femur. In stout patients it is wise to make a single U-shaped incision rather than two separate incisions.

adjacent to the trochanter. They are particularly liable to non-union, probably owing to an interposition of the reflected fibres of the capsule between the fragments. The operation consists in a U-shaped incision, the front limb of which runs vertically down from the anterior superior spine, while the posterior limb runs down from the tip of the great trochanter and curves round anteriorly to join the other. The

joint cavity is opened between the rectus femoris and the glutei muscles, and the line of the fracture is identified and cleared of blood-clot and capsule. A bone-peg roughly square in section, 4 in. long and ½ in. thick, is cut from the crest of the tibia. A point is selected on the outer surface of the great trochanter, just below its most prominent part, in a line with the axis of the femoral neck, and a hole is drilled from this point through the line of the fracture into the head by a ⅜ twist drill; the bone is then held in such a position that the fracture surfaces are closely apposed, and the peg is driven into place. (Fig. 840.) It will be noted that a comparatively large square peg is driven into a smaller round hole. There is no difficulty in doing this, because the bony tissues concerned are of an open, cancellous character into which the square peg will fit very firmly.

Ununited fractures of the neck of the femur constitute a difficult problem in treatment. The condition is nearly always associated with great absorption of the neck, and therefore does not permit of any grafting operation, even apart from the fact that the patients are generally old and feeble. Two measures of relief are, however, possible. In the first place, a well fitted walking calliper splint, which may be provided with a lock joint at the knee, will serve to take the patient's body-weight when walking. By this means a great deal of pain and insecurity may be overcome. Secondly, the head of the bone may be removed by an open operation. This by itself will serve to increase the mobility of the hip and lessen the pain on walking. A further procedure, to fit the shaft of the bone, or rather the root of the neck, into the acetabulum, has been suggested by Whitman; this consists in separating the upper part of the great trochanter from the neck and shaft of the femur and shaping the remains of the neck to fit into the hip socket, the trochanter subsequently receiving a lower attachment to the shaft, and the leg being put up in a position of extreme abduction and maintained in this position by a plaster case for six weeks.

The trochanters.—Separation of both trochanters is a common result of fractures of the base of the neck of the femur. But either trochanter may be broken off without other injury, the great trochanter by direct violence and the lesser by the muscular pull of the ilio-psoas muscle. Neither of these latter injuries requires any special treatment beyond rest for a few weeks.

Separation of the epiphysis of the head.—The head of the femur has a separate centre of ossification, and does not join the neck until the age of 18 or 20. This epiphysis may become separated by any act of indirect violence, but it is usually only partial in its extent. This so-called "slipped epiphysis," which is comparatively common between the ages of 10 and 14, is generally associated with a comparatively trivial injury which causes some

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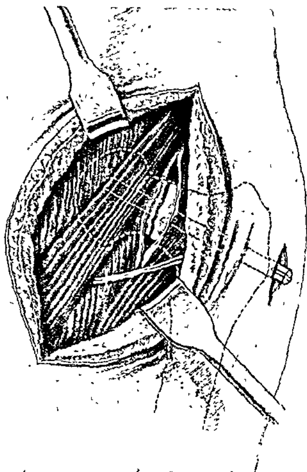


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limping and pain but does not prevent the child from walking. Very frequently the injury is entirely overlooked for some months, and it is probable that in these circumstances the deformity gradually becomes greater. On examination the limb is found to be adducted, and owing to the tilting of the pelvis it is *apparently shorter than the sound leg*, although its actual length is not lessened by more than half an inch. Movements of extension and flexion of the hip are normal, but abduction *is limited*. A radiogram shows that the neck of the femur has been pushed upwards so that its axis is above that of the head. If the condition is allowed to persist without treatment the neck gradually reforms on a new axis corresponding with that of the head. In this way the neck comes to have an angle of 100° or even 90° with the shaft, thus constituting *one form of adolescent coxa vara*. The *treatment* of slipped epiphysis will depend upon the stage at which the deformity is recognized, as well as upon its degree. If recognized soon after the accident, an attempt should be made to replace the neck in proper alinement with the head by forcibly abducting the femur and so using the upper edge of the acetabulum as a fulcrum against which to lever the neck of the bone. At a later stage, when displacement is very pronounced but union has occurred in faulty position, the hip-joint *must be opened, the junction between the head and the neck separated* by a chisel, and the head fixed on to the neck in correct position by means of a bone-nail. In a late stage of the deformity, when the neck has been remodelled into a varoid deformity, the treatment should be osteotomy through the trochanter, the leg being fixed in full abduction.

2. **The shaft.**—The shaft of the femur may be broken (Plate 137, Fig. 6) in any position between the trochanters and the condyles, but for the purposes of description it is convenient to divide it into thirds, injury to each of which has its own characteristic shape, deformity, and complications.

Upper third.—*The fracture usually occurs just below the small* trochanter, and may be either transverse or oblique, the former being more common. The upper fragment is tilted forwards by the ilio-psoas and abducted by the muscles attached to the great trochanter. The lower fragment falls backwards by its own weight and is pulled inwards by the adductors and upwards by the hamstrings. Thus the separation of the fragments may be so great as to allow the interposition of a considerable bulk of muscle tissue, which may lead to non-union, *particularly* if adequate treatment is delayed for any length of time. In any method of *treatment* that is adopted, it is essential that the shaft of the bone be brought up into line with the upper fragment by flexion and abduction of the thigh. *After consolidation* has taken place the fracture must be protected by means of a calliper splint for a long period,

otherwise bending at the site of the fracture will occur and a varoid or adduction deformity will result.

Middle third.—In this region, too, the fracture may be either

fragments, with shortening of the limb by about 1½ in. With this there is usually associated angulation, backwards or outwards, the former being due to gravity and the latter to the action of the adductor muscles. In oblique and spiral fractures one or both of the sharp fragments may be driven into the surrounding muscles and thus make reduction difficult. In the *treatment* of this fracture special care must be taken to sling the thigh in such a manner as to restore the natural anterior bowing of the femur.

Lower third.—In this region the fracture may be transverse, when it is due to direct violence, or oblique, when due to indirect. In both the lower fragment is flexed at the knee-joint by the action of the gastrocnemius, a deformity which is increased in the case of run-over accidents by the direction of the fracturing force. The sharp end of the lower fragment may press against the nerves and vessels in the popliteal region, causing severe pain shooting down the leg, extravasation of blood, or interference with the circulation in the leg. In oblique fractures the upper fragment has a sharp point directed forwards; this may be driven downwards so as to penetrate the quadriceps muscle, and it may then come out through the skin, or may pierce the synovial membrane of the knee-joint. In *treatment*, it is important to bear in mind the tendency of the lower fragment to backward displacement. To remedy this, traction must be applied to the thigh with the knee flexed. If any degree of backward displacement is allowed to persist, it will lead to a condition of genu recurvatum when the patient begins to walk.

3. **The lower end.**—Fractures of the lower extremity of the femur include separation of one or both condyles and separation of the lower epiphysis.

Separation of one condyle.—This injury is usually caused by forcible lateral bending of the knee, one condyle then being broken off by the impact of the tibia while the opposite lateral ligament may be torn. The line of fracture runs obliquely downwards from the shaft into the intercondylar notch, thus opening up the knee-joint. Such an injury will cause much effusion into the knee-joint, accompanied by a deformity of genu valgum or varum, corresponding respectively to separation of the external or the internal condyle. The *treatment* will vary according to the amount of displacement present. If the fracture consists of a mere fissure without displacement, massage

and early mobilization are indicated, the limb being kept for a time upon a back splint and then put into a walking calliper for some months. If there is pronounced displacement, open operation is advisable. The knee-joint is freely opened by an anterior incision and emptied of blood-clot, the separated condyle being accurately replaced and fixed to its fellow by a steel bolt passing right across the bone and secured by a nut which is applied through a small separate incision over the uninjured condyle. The head of the bolt and the nut should be provided with ample washers to prevent sinking into the soft tissue of the bone. (Fig. 841.)



Fig. 841.—Fracture of lower end of shaft of femur treated by a bolted plate.

Y-shaped fracture.—In this the two condyles are separated from the shaft and from one another. It is usually caused by a fall upon the feet, the tibia being driven like a wedge upwards between the condyles, or by a fall on the bent knee, in which case the patella acts in the same way. The pointed extremity of the shaft passes downwards into the knee-joint between the two condyles. There is great widening of the knee-joint, and much effusion of blood. *Treatment* should always be by open operation, performed as early as possible after the injury, and consisting of two anterior lateral incisions on either side of the patella. Two lateral plates should be applied to the sides of the shaft of the femur, the lower end of these embracing the condyles, and a bolt should be passed right through the two condyles from side to side in the lowest hole of the plate,

Two bolts at least should transfix the shaft of the bone, and fix the plates to it. In order to make the holes for these bolts through corresponding holes in the plates, a special drill guide is used.

Separated lower epiphysis.—The lower epiphysis does not join the shaft of the femur until the twentieth to the twenty-fourth year. Its separation usually occurs in boys by forcible hyperextension of the knee. The epiphysis becomes flexed at the knee-joint, so that its broken surface looks backwards. At the same time the shaft of the bone is driven behind the epiphysis into the popliteal space. The cavity of the knee-joint is usually opened. *Treatment* consists in manipulation under full anæsthesia. The knee is fully flexed and the upper part of the tibia is pulled away from the thigh. Reduction should be confirmed by means of radioscopy. The knee is kept fully flexed without any splint for four weeks, massage being begun immediately and gentle movements of the knee at the end of the second week.

General Treatment of Fractures of the Femur

There are several reasons why fractures of the femur present a more difficult problem of treatment than those of any other bone in the body. It is the largest and longest bone; it is the bone which is the most deeply buried in soft parts; the muscles attached to it are very strong and exert a great distorting influence; its adequate repair requires that it should be restored to its full length and that its correct alinement should be preserved, as it has to act as one of a pair; and lastly it has to support the full weight of the body on a skeletal strut which is normally curved and which tends to bend under the body-weight if the reparative material is not perfectly solid.

On the other hand, the discussion is simplified by the fact that incomplete fractures of the femur or those with no displacement are very uncommon, so that it is unnecessary to deal with treatment by massage and mobilization alone. The subject has been confused in the past by the description of a multitude of splints while the underlying principles of treatment were overlooked. All the really efficient methods of treatment can be placed in two great groups—treatment by *traction* and treatment by *open operation;* but there are many good methods in each group. For the sake of simplicity they may be classified in the following scheme:

1 Traction.

A. *Fixed or passive traction* —The leg is pulled into correct length and alinement and then set in a fixed appliance.

(*a*) Thomas's splint.

(*b*) Plaster of paris.

B. *Mobile or active traction.*—A weight is fixed to one end of the leg and made to exert a constant traction upon it while the other end of the leg is fixed.

(*a*) Sling and weight.
(*b*) The lower end of the leg is fixed and elevated, the body acting as traction-weight.
(*c*) The leg is slung in splints, and weight applied to the latter.
(*d*) Cradle splint; the leg is slung, and weight applied by means of a self-contained apparatus.

2. Operation.

A. *Plating.*
(*a*) Fixed by short screws.
(*b*) Fixed by transfixing bolts.
B. *Encircling bands or wires.*
C. *Intramedullary pegs.*
D. *Bone-grafts.*

Fixed or passive traction. The Thomas splint (Fig. 842, 1).—The Thomas bed-splint for fractures consists of an oval metal ring, padded and covered with leather, and two side-bars of $\frac{3}{8}$ in. steel rod joined together below the foot by a cross-bar in which there is a V-notch. One side-bar is some inches longer than the other, this lying on the outer side of the thigh. In the correct pattern of the splint the thigh-ring is tilted backwards. It is not exactly oval, but somewhat triangular in outline, the three sides of the triangle corresponding to the inner, front, and back aspects of the limb; also, the side-bars of the splint are not in the middle of the ring, but nearer the front than the back. This shape is designed so that the ring shall snugly fit the upper part of the thigh, lying against the tuber ischii and the fold of the groin in front. The forward position of the side-bars is intended to give the splint a more efficient action in slinging the leg forwards so as to prevent backward sagging. This accurately-made type of splint will, of course, be different for the right and the left leg. The Thomas splint commonly used for fracture treatment differs from the above pattern in having an oval ring, the side-bars midway between the back and the front and the ring not being tilted, so that the back and the front are at the same level. In using this pattern the ring does not fit closely but loosely round the thigh. The advantage of the modified pattern is that the same splint may be used for a right or a left leg, and that as the fit is loose it is not necessary to keep so many sizes in stock. The drawback is that, as it does not fit snugly against the thigh, it is apt to get out of place, either slipping up behind the ischium or pressing upon the perineum and anus. If, therefore, the Thomas splint is to be used with success in the manner originally intended, it ought to be of

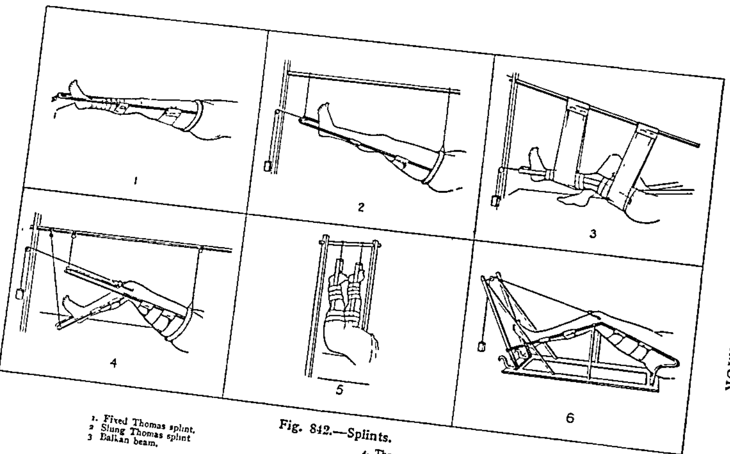


Fig. 842.—Splints.

1. Fixed Thomas splint.
2. Slung Thomas splint
3. Balkan beam.
4. Thomas splint with hinged attachment at knee-joint.
5. Child's legs slung to a gallows splint.
6. Hey Groves cradle

the correct size and shape. Another useful modification of the splint, which does not interfere with its essential principle, is the addition to its lower cross-bar of an adjustable screw by which traction may be applied (Fig. 843).

As a preliminary to the application of the splint the leg is provided with two traction bands running down the sides of the limb and attached to it by evenly-applied circular strips of adhesive plaster. An anæsthetic is then given, the foot is threaded through the ring of the splint, and full traction is made upon the leg while the splint is pushed up firmly until it engages against the tuber ischii. The leg should be pulled upon until it is as long as the sound limb, or a trifle longer, and it should be thus firmly held while the traction bands are either passed round the side-bars and then tied to the V-notch or else fixed to the transverse bars carried by the adjustable screw. The use of the latter device has this advantage, that a little extra traction may be applied after all other adjustments have been made, and it can also be used to apply additional traction a day or two after the original adjustment.

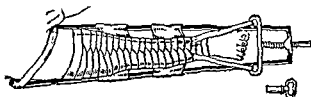


Fig. 843.—Fractured femur treated by a Thomas splint. The extension is made by a screw and key.

After the traction has been adjusted, metal trough splints of thin malleable iron are applied to the back and front of the thigh, and slings are passed under the thigh and leg from one side-bar to the opposite so as to secure a slight forward bowing of the femur. A roller bandage is now passed round the splint and thigh and the adjustment is complete. It only remains to safeguard the position of the foot so as to prevent inversion or eversion of the leg- or foot-drop. This may be done most conveniently by fitting a small wire frame on to the side-bars of the splint opposite to the foot and slinging the foot up to this frame. The position of the fracture should be verified by means of the X-rays; if it is satisfactory, nothing further is required for four to six weeks, at the end of which period consolidation should be sufficiently firm to allow removal of the splint and permit the patient, provided with a walking calliper, to get up.

The only points which require attention after the Thomas splint has been adjusted relate to care of the skin on which the ring presses and to maintenance of the traction. The area on the back and inner sides of the thigh is cared for by daily application of spirit and powder, with a

slight change of the actual part of the skin pressed upon, secured by pulling the skin up or down. If the traction bands stretch, the slack should be taken up from time to time. In cases in children this method may prove to be ideally simple and efficient, but in muscular adults it is liable to several drawbacks. The amount of traction necessary is very considerable, and will cause so much pressure upon the ischium as to make the skin over this process sore. For the same reason there will be great liability for the adhesive plaster to slip from its attachment, or, if it is applied tightly, to make the leg sore.

The essential principle of this method is that of producing full and complete reduction of the fracture on the occasion of its first application; assiduous watch must be kept to see that the corrected position is maintained and not lost owing to relaxation of the traction bands. A serious drawback is that the whole leg is kept in a straight line with both hip and knee fully extended. Thus this method will not meet the case of a fracture of the upper third with marked tilting forwards of the proximal fragment, or of the lower third with tilting backwards of the distal fragment. Finally, as the knee-joint is maintained in a rigidly extended position, in many cases *restoration of its mobility will take a long time.*

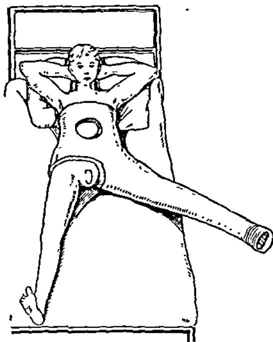


Fig. 844.—Plaster-of-paris spica.
(*Keen's "Surgery."*)

The method is most suitable, then, for fractures in the middle of the shaft without much displacement in children or young adults, and even in such cases most surgeons prefer, in using a Thomas splint, to adopt the *system of mobile or active traction*, in which the leg in the splint is slung up off the bed and weight traction is applied to the lower end of the splint. (Fig. 842, 2.)

Plaster of paris (Fig. 844).—The use of plaster of paris in the *primary treatment of fractures of the thigh* has very limited but definite scope. Its principle of action is precisely the same as that of the

Thomas splint when used for fixed traction. That is to say, success depends upon the complete correction of deformity being achieved before the plaster is applied. When once this has been done, no further adjustment is possible, and apart from attention to prevent soreness, nothing more is necessary until consolidation is complete. An efficient suspensory apparatus in which the body and leg can be slung while extension and abduction are applied to the fractured leg is essential. The best apparatus for this purpose is a specially designed fracture table, such as Hawley's, but if this is not to hand, a device which will serve the purpose can be improvised by placing a sufficiently strong beam over the bed, to which the body and legs are slung. The pelvis must be fixed, and counter-extension provided, by means of a strong padded perineal band passed round the pelvis on the sound side. Under full anæsthesia the leg is pulled down and abducted until it is slightly longer than its fellow. The plaster is applied from the toes to the lower part of the chest, care being taken to secure that the foot is dorsiflexed, that the toes point forwards and a little outwards, that the knee is slightly bent, that the femur is bowed forwards in its natural curve, and that the thigh is slightly flexed and fully abducted on the pelvis, the bony points of the latter being specially protected by extra padding The indication for this treatment will vary very much, and it will be seldom resorted to by those who are practised in the use of apparatus which applies mobile traction. The cases in which it is especially indicated are those of fractures of the neck of the femur when operation is impossible, and those of fractious or undisciplined patients, whether old people with dementia, middle-aged lunatics, or spoilt children.

Mobile or active traction.—The inherent difficulties and disadvantages of fixed traction, even if applied efficiently by a Thomas splint or by plaster of paris, and still more if applied inefficiently by wooden or metal splints which are merely attached to the leg, have long been demonstrated. The inevitable tendency of all such fixed systems is for the displacement to be under-corrected at the outset and to be gradually increased as the adjustment of the apparatus becomes slack during the course of repair. It is far better to counteract the ever-present active autotonic contraction of the thigh muscles by a constantly acting traction force, the corrective influence of which will not be modified by changes in position of the patient's body or joints. The weight-extension system was first used and popularized by Bardenheuer, who in fractures of the leg used no splint or sling whatever, but merely attached heavy weights to the distal part of the limb, hanging these weights over the end or side of the bed. But in reality the no-splint method simply means that the frame of the bed is used as a splint, and it is a matter of practical experience that this may be supple-

mented with great advantage by the addition of some framework to which the limb may be slung, the joints being adjusted in special positions and the direction of the traction force varied at will. It is fallacious to suppose that the discarding of all apparatus will simplify the traction method. On the contrary, it usually complicates it, first, because a much greater force is required to extend a leg which lies on the bed than one which is slung up; and, second, because the want of precision in the direction of the main pull has to be compensated by secondary side or cross pull to correct deviation.

The overhead sling, or Balkan beam. (Fig. 842, 3).—Probably the nearest approach to a combination of simplicity and efficiency is the method of slinging the leg to a beam over the bed and then applying longitudinal traction to the limb by means of a weight, cord, and pulley. The suitability of this method to meet conditions of emergency when complicated apparatus is unattainable was demonstrated during the Balkan war, and the device is therefore generally known as the Balkan beam. In its original simplicity, and as it should now be used in cases of emergency occurring in private houses, the apparatus consists of two uprights fixed to the head and foot of the bed, and an overhead bar which is borne by the uprights. This overhead beam should be of stout wood (about 3 in. by 4 in.) so as to be amply strong

that at the foot, so that when the overhead beam is in position the latter should be inclined upwards towards the foot of the bed at an angle of 30°. The upright at the head should be as near the edge of the bed on the sound side as possible, while that at the foot should be near the opposite corner—that is, on the side of the injured leg. The traction cord is attached to the leg by means of adhesive strapping or glue; adhesive strapping is the method generally used when the proper material is available. A long strip of the stoutest strapping is attached to the sides of the leg from a point well above the seat of fracture. In the loop of the longitudinal piece below the foot is placed a square piece of wood, wide enough to prevent pressure upon the ankles. The wooden piece is perforated by a central hole which takes the traction cord. The longitudinal strapping is further fixed to the leg by means of circular turns of lighter strapping evenly placed from the ankle up to the knee, and from above the knee to the highest part of the side strap. The knee- and ankle-joints should be free from circular turns, and the crest of the tibia should be protected from pressure by a double thickness of lint. A bandage is placed over the whole limb further to secure the adhesion of the plaster.

Glue may be employed instead of adhesive strapping. It is much

cheaper, but requires more skill and experience in its application, and it is chiefly useful when a large number of fractures have to be treated at the same time. The preparation of glue commonly used is that advised by Sinclair, and consists of 50 parts each of dry glue and water and 2 parts each of glycerine, calcium chloride, and thymol. The limb need not be shaved, and if the glue is applied directly to it by a brush, great care should be taken that it is not so hot as to burn the patient. Two

applied to its surface, this being covered by a second bandage. The leg is slung to the overhead beam by two wide slings such as can be made from roller towelling. The thigh should be elevated at an angle of 30°, that is parallel to the overhead beam. The knee is flexed, the leg being kept nearly horizontal. The traction cord is brought down to a pulley fixed at a suitable height to the lower upright, and a weight of about 15 lb. is attached to its lower end. If a broad curved metal splint is bandaged to the back of the thigh, it will serve to distribute the tension of the upper sling more evenly. The patient is prevented from being pulled down the bed by raising the foot of the bed on 8-in. blocks and by passing a well-padded perineal band round the upper end of the sound leg and tying it to the head of the bed. Foot-drop should be prevented by the use of a bed sock, the upper part being fixed to the side-straps and the toe being tied to the overhead beam. In a recent fracture of the femur it will be found that after twenty-four hours the injured leg has been pulled down until it is the same length as the sound one. The weight can generally be reduced to 10 lb. at the end of three weeks, and discontinued at the end of six weeks, when the patient should be fitted with a walking calliper splint.

From the end of the first week of treatment, and thence on daily during the whole course, the knees should be straightened or bent once or twice a day. This is done by holding the lower end of the femur with the same amount of traction as has been exerted by the weight and then releasing the weight and lower sling. The chief difficulty encountered arises from the adhesive appliance stretching or giving way, or making the leg sore. If this occurs later than the fourth week it may usually be met by reapplication of the adhesive appliance, any sore points being protected by lint and ointment. If it occurs earlier, it will be necessary to have recourse to a transfixion pin or callipers.

—This method is only used for

Traction

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ith a suffi-

cient degree of tension to lift the buttocks clear of the bed. A light restrictive harness should be placed round the child's body to prevent him from slipping down. The nurse should be cautioned against putting a pillow or air-cushion under the buttocks. This position should be maintained for three or four weeks, at the end of which time union is usually firm enough to allow of the substitution of a light calliper splint. The advantages of using this method are that it is so readily improvised and that it leaves the perineum free for nursing purposes.

Traction applied to a splint in which the leg is slung (Fig. 812, 2).—The advantages of placing a broken leg in some kind of rigid splint or frame are obvious, as providing comfort and security. This fixation of the leg, with the additional advantage of continuous weight-traction, can be secured by first placing the leg in a light frame [illegible]

end of the wire frame, in which the leg is slung by flannel strips in the Hodgen method. As originally described, both suspension and traction are made by a system of cords tied to a post at the lower end of the bed; in this way suspension and traction are made by the same cord, and the actuating weight that produces traction is that of the leg itself. The amount of traction will depend upon the points of attachment of the cord and its direction. It will form a much simpler and more efficient appliance if the splint in which the leg is slung is tied to an overhead beam, and if then a weight traction is applied by means of a pulley-wheel and cord to the lower end of the splint, pulling in the axis of the leg

It will usually be found, however, that this principle is more easily [illegible] The [illegible] which [illegible] hereas the Hodgen splint, being incomplete behind, is only secured in position by the flannel strips which tie it to the leg, any adjustment of these strips being liable to disturb the whole counterpoise system. Thomas's splint was used in this manner by many surgeons during the war, and constituted a most efficient method. The leg, with traction bands attached to it, is passed through the ring of a Thomas splint and pulled down until the ring lies against the ischium, and the traction bands are tied to the lower end of the splint. The leg is then slung to the bars of the splint by broad strips of bandage, lying underneath it, and so tightened as to secure slight flexion of the knee and forward bowing of the femur. The splint is then slung to an overhead beam by at least two cords, one of which is tied to the front of the ring and the other near the lower end of the splint. The ring of the splint need not fit the

thigh very closely, as the upper suspension cord will serve to keep it from slipping over the tuber ischii. The traction-weight is tied to the lower end of the splint, and the cord made to pass over a pulley so placed as to pull in the line of the leg. The advantages of this method over the original Thomas method, with its fixed or passive traction, are as follows: (1) *It embodies the principle of a constant pull counteracting the muscular traction throughout the whole period of repair.* (2) It is not necessary to secure an accurately fitting ring, because counterextension is not made from this. (3) It is *much more comfortable, since the patient is relieved of the constant pressure of the ring upon his pelvis.* It is, however, subject to the same difficulty as was mentioned in the

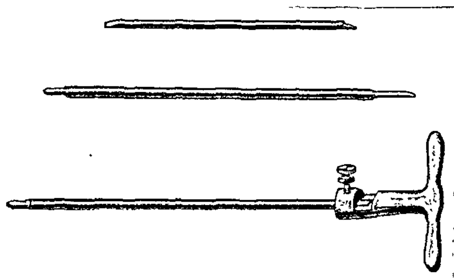


Fig. 845.—Transfixion pins and handle.

case of the Balkan beam—the liability of the adhesive appliance to be dragged off or to make the skin sore; and it is open to an objection from which the Balkan beam is free—that it keeps the knee in an extended position and will cause stiffness of this joint. Both these difficulties have been overcome by the modifications next to be described.

Transfixion pin or calliper with flexible knee.—By far the most powerful and efficient method of applying traction *to the fractured femur is that of applying* the traction force by means of a pin thrust through the lower end of the bone. The steel transfixion pin (Fig. 845) is 6 in. long and $\frac{3}{16}$ in. thick, with a chisel point at one end, and a flat surface at the other which fits into a handle. The patient having been anæsthetized and the skin round the knee sterilized, the pin is made to perforate the femur from side to side, just

above the condyles (Fig. 816). A point should be selected at least one finger-breadth above the most prominent part of the internal condyle, and at the moment of transfixion the skin should be drawn tightly upwards towards the hip, so that when traction is applied through the pin it may not drag upon the skin. It is important to transfix the lower part of the shaft and not the condyles of the femur, because the latter are dangerously near the synovial membrane of the knee-joint, and because they are composed of soft cancellous bone, in which the pin is liable to be loosened by the action of the weight. The pin being in position, the points of its entrance and emergence are protected by dressing and bandage, and a U-shaped steel rod is attached to its projecting ends to give attachment to the traction-cord. This is brought

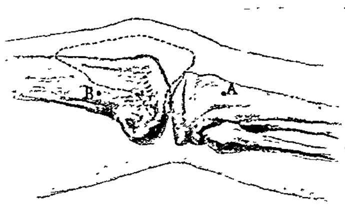


Fig. 816.—B and A, points of transfixion of femur and tibia. The dotted line shows the limit of synovial membrane.

down to the lower end of the splint, wound round it, and then passed on to a pulley at the bottom of the bed, where it is attached to the weight.

Objection has been made to the use of a transfixion pin on the grounds that it may lead to a septic sinus running into the bond. The fear of this complication has been greatly exaggerated, and, except in those cases of septic gunshot fractures where the patient is suffering from general septicæmia, it may be ignored. But to avoid this penetrating action of the transfixion pin an instrument like an ice-

afforded by either will enable traction to be made on the distal fragment of the bone with a much more powerful effect than is possible when this is done by adhesive appliances attached to the skin. More-

over, either of them can be relied upon to provide a secure hold for a period of four to six weeks Lastly, the knee-joint will not be immobilized, and can be moved daily during the course of treatment.

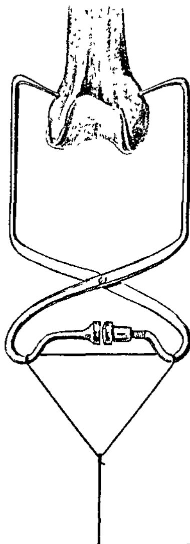


Fig. 847. — Pearson's extension calliper. The handle on the right side has a screw cap; the adjustment of this regulates the depth to which the points of the calliper can penetrate the bone.

In cases of infected fractures of the femur, or of fractures which involve the condylar region, transfixion may be made through the tibia just behind and below the tubercle A pin should be used 4 in. long and $\frac{1}{8}$ in. thick. It can be left in place for a much longer period than a pin transfixing the femur—for eight to twelve weeks if necessary. The use of the tibial site for transfixion does not interfere with the movements of the knee-joint if the lower end of the femur is steadied by the hand while these movements are being carried out.

Mobilization of the knee.—If traction on the femur be made by means of a transfixion pin or calliper, the leg below the knee may be left entirely free of slings or bandages. A light wire frame is hinged on to the back of the Thomas splint (Fig. 842, 4), the hinge being placed just opposite the knee-joint. This frame is converted into a support for the leg and foot by flannel slings and *by a wire frame foot-piece.* When this adjustment has been made, the leg can be moved at the knee-joint, and the best plan is to suspend it so that it lies in a position of moderate knee flexion, from which position it is daily moved to full extension and full flexion. As a result, when the femur has united, the patient will be ready to walk with mobile knee without the pain and delay associated with restoration of its mobility by exercises.

Correction of lateral displacement.—It often happens that, when a femur has been subjected to traction, full length and good alinement are obtained, but the ends of a transverse fracture remain out of apposition—that is, there is persistent lateral displacement. Although such lateral displacement may not in itself be productive of much harm, there are reasons why it should, if possible, be corrected. Thus, union will be quicker, firmer, and accompanied with less callus, traction can be discontinued at an earlier date, and there will be much less fear of late displacement.

Lateral displacement can be corrected in several ways. The simplest is to increase the amount of axial traction so that the fragments are pulled clear of one another with a definite gap between them, when the natural elasticity of the periosteum and soft parts will tend to bring the ends into alinement. Or, if the fracture can be examined by the X-rays without disturbing its adjustment, it is often possible to adjust the fragments so that the ends become interlocked. Or lateral pressure may be easily applied to the displaced ends by means of pads or elastic bands attached to the side bars of the splint.

The cradle splint (Fig. 812, 6)—The cradle splint, which was first designed and used during the war, introduces no new principle, but is so designed as to sling the leg off the bed in a position of flexion of the hip- and knee-joint, and to provide for weight-traction in the axis of the femur, by means of a self-contained apparatus. It consists of a wire frame longer on the outside than the inside, supported on a metal base which bears two uprights at the lower end. The uprights carry a cross bar with two pulley-wheels which can be adjusted at different heights. The splint is prepared for use by placing slings of flannel or rubber across the frame, and in the cradle thus prepared the leg is laid with the hip and knee flexed. The pelvis is fixed to the upper end of the bed by a perineal band round the sound side, and the splint itself is fastened by hooks to the lower bar of the bed. Traction is applied to the leg by one of the usual methods, either adhesive plaster, or a transfixion pin passed through the lower end of the femur or upper end of the tibia. The traction cord passes from the square reinforced foot-piece of the strapping, or from the horseshoe holding the transfixion pin, over one of the pulley-wheels at the lower end of the splint, and thence down to the weight

The adjustment of the weight may be facilitated by the use of two pairs of pulley-wheels. One pair is on the lower bar of the splint, the other is on the horseshoe which embraces the transfixion pin. The cord used for traction is tied to the bar which carries the splint pulley-wheels, and is then wound round the pulley-wheels on the horseshoe and the splint alternately. After it has passed over the second splint pulley-wheel it falls vertically to the weight. With this adjust-

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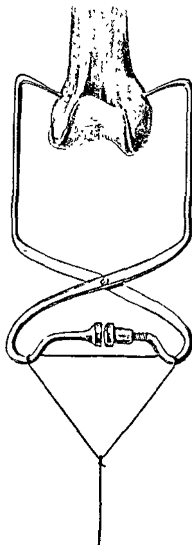


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In cases of infected fractures of the femur, or of fractures which involve the condylar region, transfixion may be made through the tibia just behind and below the tubercle. A pin should be used 4 in long and ⅛ in. thick. It can be left in place for a much longer period than a pin transfixing the femur—for eight to twelve weeks if necessary. The use of the tibial site for transfixion does not interfere with the movements of the knee-joint if the lower end of the femur is steadied by the hand while these movements are being carried out.

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ment there will be a fourfold multiplication of the weight used, so that a 20-lb. pull will be obtained by means of a 5-lb. weight. Similarly, by altering the adjustment so that the cord shall only pass round three pulleys, or two, or one, the traction force will be reduced to 15 lb., 10 lb., or 5 lb. respectively. The foot is bandaged to a special foot-piece, shaped for the supporting of the arch, which rests on the side bars of the splint by an adjustable cross piece running on rollers. The special advantage of the cradle splint is that in the compass of one single and portable apparatus it contains all that is necessary for slinging the leg off the bed and applying the most powerful weight-extension.

Choice of method.—It is not intended, by the description of several different methods or appliances for the treatment of fractured femurs, to suggest that they are all of the same value, so that they may be chosen indiscriminately. But it is important that all fractures of the femur should be treated by weight-traction while the leg is freely slung off the bed, with the following exceptions, in which the special methods indicated should be employed: (1) Fractures of the neck of the femur and those in restive, undisciplined patients—plaster of paris. (2) Children up to the age of about 5 or 6 years—vertical suspension. (3) Patients between the ages of 5 and 15 with fractures of the shaft, not presenting much displacement—fixed Thomas splint. (4) Cases of marked displacement which is not satisfactorily reduced by pin-traction within one week—open operation. (5) All complete fractures in adults, and especially those with septic wounds or much comminution of the fragments—by a sling splint or cradle splint. When displacement is slight or the patient has weak muscular development, adhesive application of the traction will be sufficient. Much displacement and strong muscular development indicate the necessity for the use of a transfixion pin.

Treatment of fractured femur by operation (Fig. 818). Open operations.—As to the indications for open operation, opinions will always, probably, differ. Where large numbers of cases are constantly being treated in a special department of a large hospital, so that a team of surgeons, assistants, and nurses become familiar with the use of traction apparatus, very few cases will require open operation. The broad indication for this procedure is, in fact, the persistence of great displacement of fragments in spite of well-applied traction. In such cases operation offers the chance of more rapid union and of a more perfect anatomical and functional result in muscular adults. Two types of fracture have already been mentioned in which open operation should be the method of first choice, namely, certain fractures of the neck of the femur, and fractures involving the separation of one or both condyles. One further remark is necessary before describing individual operations. Operative treatment consists

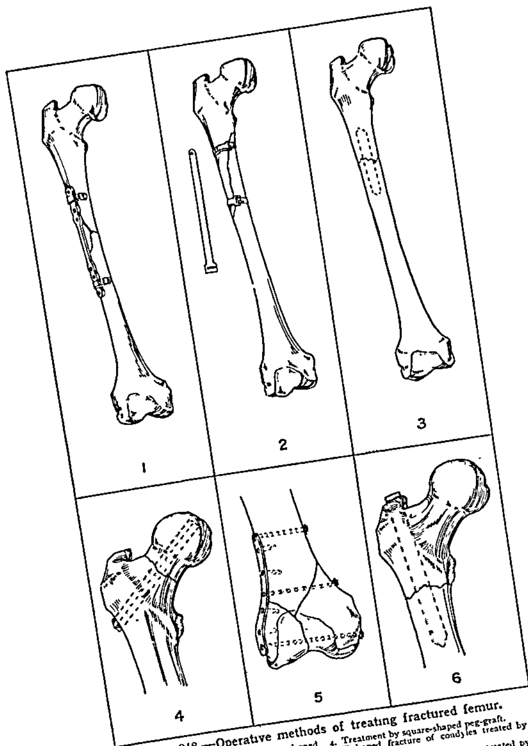


Fig. 848.—Operative methods of treating fractured femur.

1 Butterfly fracture of femur treated by clipped plate.
2 Oblique fracture treated by two Parham bands.
3 Intramedullary peg for transverse fracture of upper third
4 Treatment by square-shaped peg-graft.
5 T-shaped fracture of condyles treated by bolted plate.
6 Fracture below small trochanter treated by long bone peg driven down from top of great trochanter.

merely in the accurate application of an internal splint to the broken bone. It will not take the place of natural repair, neither will it obviate the necessity for the use of some external appliance, such as a traction apparatus, or at a later stage the walking calliper splint, which must still be used to prevent angulation.

Plating.—Plating of fractured femurs has been used rather indiscriminately for many cases which can be dealt with better by other methods. *It should be reserved for butterfly fractures of the shaft*—that is, cases where, in addition to the two main fragments, there is a small intermediate piece which often lies crosswise and is not amenable to orientation by a traction appliance. A long external incision will be necessary through the fibres of the vastus externus muscle. The fragments having been placed in correct position, a plate about 6 in.

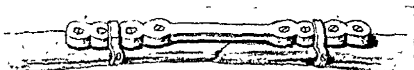




Fig. 849.—Plate with clips.

long is screwed on to the outer surface of the bone. In order to give more secure fixation, a metal clip is used at each end of the plate, which is fastened by screws that converge at right angles to one another (Fig. 849). *This gives much greater security than a set of screws placed all in one line, and holds the plate from springing away from the bones* at the two ends. When the fracture involves the lower third of the femur a *bolt* (Fig. 848, 5) should be passed *transversely through* the bone at the lower end of the plate, and secured by a nut applied through a separate incision on the inner side of the leg.

Pegs.—Clean transverse fractures of the femur with persistent lateral displacement should be treated by the use of an intermedullary bone-peg (Fig. 848, 3). The peg should be from $\frac{3}{8}$ in. to $\frac{1}{2}$ in. thick and 3 in. long. A short incision is made over the outer aspect of the fracture, and the broken ends are drawn out into the wound and drilled by a twist *drill of such a size as will just remove the friable bone of the marrow* cavity. The peg, which has a central stop, like a cricket bail, is driven

into one fragment, and the other fragment is made, by angulation and traction, to engage the projecting end of the peg; then by gradually

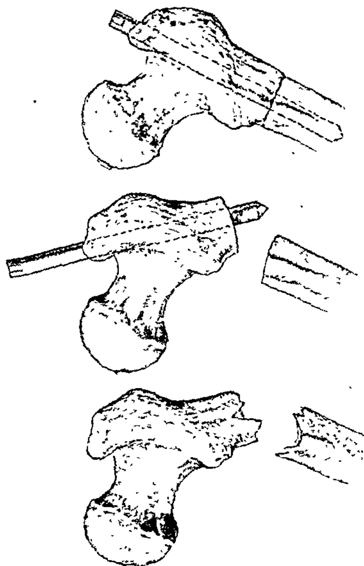


Fig. 850.—Pegging upper end of shaft of femur, by driving a peg through top of great trochanter.

straightening the leg it will slip into place. If the tension is too great

Transverse fracture through the trochanters, or just below the level of the small trochanter, is best treated by driving the peg downwards into the shaft of the bone from the top of the great trochanter (Fig. 848, 6) The initial steps of this operation are similar to those described above. When the upper fragment is drilled, the drill is passed on until it is felt to emerge through the tip of the great trochanter, when it is cut down upon through a separate incision and the edges of this incision are retracted. A peg 6 in. long without a central stop is passed into the hole at the top of the trochanter and driven down until it appears in the fracture, when it is made to engage in the lower fragment and then driven home (Fig. 850).

Bands or wires.—Oblique or spiral fractures are not suitable for plating or pegging if the length of the fracture is more than twice the breadth of the bone. In such a case the fracture should be united by two encircling bands of metal, placed near its extremities. The fracture must be accurately reduced and held by a strong clamp. A Parham band (Fig. 848, 2) or a double stout iron wire loop is passed

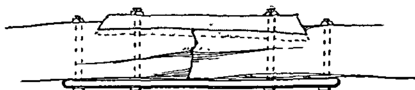


Fig. 851.—Fracture of femur united by a graft and plate bolted together.

round the bone above and below the clamp and firmly fixed before the latter is removed.

Bone-grafting.—The femur is a difficult site for the successful application of a bone-graft, because union is slow and there is great tendency for the fixation between the graft and the bone to be disturbed. In gap fractures it is wise not to attempt to bridge the gap by means of the graft; the ends of the fragment must be refreshed and brought together, and the graft merely used as a method of inducing living union. Various methods may then be employed to supplement the strength of the graft and to secure its firm fixation by mechanical means. This is best done by a two-stage operation. In the first stage the scar tissue is removed, the ends of the bone are refreshed and fixed by a plate applied to the inner aspect of the femur. In the second stage, performed two or three weeks later, an inlay graft is placed in a trough cut on the outer aspect of the femur and fixed in position by means of two transfixing bolts which pass through holes in the plate and through the graft (Fig. 851).

After-care of a fractured femur. — As a general rule, fractures of the femur have undergone solid union in a period of about

six weeks. But as the femur has to bear the whole weight of the body in walking it is very liable to bend, for, although callus union may be firm, it is still capable of being moulded by pressure, so that the bone may become deformed. It is neither wise nor necessary to keep the patient in bed for several months while the callus union is becoming bony. Neither is it right that he should get about on crutches with the leg slung off the ground for any length of time, for the injured leg would be drawn inwards by the action of the adductor muscles, as well as by the action of gravity, and the femur would become bent. The best course to pursue is to continue the traction treatment until union is so firm that neither mobility nor pain at the seat of fracture is caused by manipulation. Then a Thomas walking calliper splint should be fitted. The ring should accurately fit the upper end of the thigh, being tilted backwards so that that part of the ring which lies against the ischium is the lowest. The side bars, which fit into a slot in the heel of the boot, should be made so as to be capable of adjustment in length to the extent of one or two inches. When the patient gets up, the length of the splint should be such that his heel is off the ground—that it does not come down into his boot. After a period of about six weeks the splint is shortened so as to allow the heel to come down to touch the boot. As a rule, the calliper splint should be used for about six months, being taken off every night when the knee-joint is exercised, and not put on again until the exercise has been repeated in the morning. The period of use of the calliper may be shortened in the case of children, in fractures low in the shaft with accurate union, and in oblique fractures with wide contact of the fragments. The period may have to be prolonged up to twelve months in cases where union has been slow or weak, where the contact between the fragments is bad, and in fractures of the upper third of the femur, in which there is always a tendency to adduction deformity.

THE PATELLA

Fracture of the patella may be due either to direct violence or to muscular action, the latter being far the commoner.

1. When due to **direct injury**, such as falls or blows upon the knee, the bone is broken into several fragments, but these are not as a rule much separated from each other, being held together by the overlying aponeurosis. Such an injury is usually accompanied by considerable effusion into the joint.

Treatment consists in rest on a back splint for a few weeks, with daily massage and gentle movements of the knee. It is only in those cases, usually due to gunshot injury, where some of the fragments of the broken bone have been separated from its deep surface so as to lie loose in the knee-joint that operation is required. Then the knee-

joint is opened by an incision on one side of the patella and loose fragments of bone are removed. *Cases of great disorganization of the patella have given much better results when the whole bone has been removed, with the preservation of the aponeurosis, than when attempts have been made to preserve the loose fragments, because the latter* always form an irregular bony mass which becomes adherent to the front of the femur.

2. **Fracture by muscular violence.**—This, the common accident to the patella (Plate 138, Fig. 1), is caused by a sudden contraction of the quadriceps muscle when the knee is bent and a quick movement is made to prevent the body falling after taking a false step. [illegible] to the surface [illegible] The patient [illegible] joint. Unless the swelling is very considerable a gap ½ in. to 1 in. wide may be felt between the fragments in front of the knee. The aponeurosis covering the patella is torn, and the torn fringes of this membrane curl over upon the broken surfaces of the bone, so that even if the fragments can be brought together they will not unite by bone. If the nature of the injury is overlooked, and after a short period of rest the patient is allowed to walk about, the separation of the fragments becomes more pronounced, so that in extreme cases they may lie some inches apart.

Treatment.—*Open operation should be the routine treatment* in all cases, unless absolutely contra-indicated by the condition of the patient in respect of age, debility, or disease. Exposure should be made by a U-shaped incision, the apex of the U being upwards, so that the subsequent scar may not interfere with kneeling. The skin and subcutaneous tissue of the flap are turned downwards, and the fragments of the fractured patella with its torn aponeurosis fully exposed. All blood-clot is cleared out of the joint, and the fragments of the bone are brought accurately together. The fracture may be united in various ways, of which the use of a strong circular wire is the simplest and best. Holes are drilled from side to side through both fragments as near as possible to the upper and lower borders of the bone. A stout wire loop is passed through these, and its ends are tightened while the fragments are held in close apposition. *At the places on each side of the* patella where the wire circle goes from one perforation hole to the other, a gutter should be cut in the soft parts for its reception. The wire having been twisted, its ends cut off and turned in, the aponeurosis is [illegible]

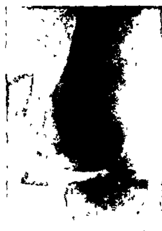


Fig 1 —Fracture of patella, before operation

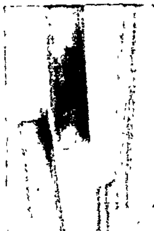


Fig. 2 —Transverse fracture of tibia and fibula, before operation.

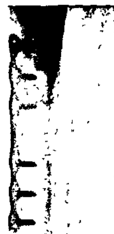


Fig. 3 —Transverse fracture of tibia and fibula, after operation.



Fig 4 —Pott's fracture with tear of internal lateral ligament.



Fig 5 —Pott's fracture with fracture of internal malleolus

(*Figs 4 and 5 are from Ironside Bruce's "Fractures and Separated Epiphyses"*)



Fig 6 —Dupuytren's fracture, showing lateral displacement.



Fig 7 —Dupuytren's fracture, showing backward displacement.

PLATE 138

applied to the knee-joint, whether this be in the nature of a twist or of a lateral shear. One or both tubercles of the spine may be broken off, and there may be a coincident damage to the crucial or lateral ligaments. At the time of the accident pain, effusion, and inability to move the knee-joint will lead to a diagnosis of sprain, and only a good X-ray picture will ensure recognition of the nature of the injury.

The symptoms of rupture of the crucial ligament are quite distinctive and unmistakable. If the anterior ligament is at fault, the head of the tibia slips forwards on the femur when the knee is fully extended. If the posterior ligament is torn, the head of the tibia slips back on the femur when the knee is flexed.

Treatment should at first be on conservative lines by a combination of rest with massage and movement. Some kind of knee-cage or walking calliper splint should be used for two or three months in order to avoid premature strain on the lateral or crucial ligaments of the knee. Treatment by operation should only be undertaken if conservative treatment has failed and if the symptoms of a loose body or of a torn crucial ligament are present. The operation requires a free exposure of the knee-joint by medial splitting of the patella, or, better still, separation of the tubercle and turning the patella upwards. A fractured spine should be removed from the joint and a torn crucial ligament replaced by a suitable substitute, such as a strip of fascia lata or the semitendinosus tendon.

3. **The tubercle.**—This structure develops as a downgrowth of the upper epiphysis, and its separation usually occurs in patients of between 11 and 15 years as the result of a violent contraction of the quadriceps muscle—the same kind of accident which in older patients will cause a fracture of the patella. Usually the tubercle is not completely separated, but is merely pulled off from the shaft below, retaining its connexion with the epiphysis above. This fracture is one variety of the condition first recognized and described by Osgood and Schlatter, and sometimes known by one or both of their names. The nature and existence of the fracture is usually overlooked at the time; the patient complains of pain and tenderness over the tubercle and of weakness of the knee-joint when he first begins to walk after recovering from what was regarded as a sprained knee. In cases of partial separation of the tubercle no treatment may be required beyond the use of a calliper walking splint for about three months. If a complete separation of the tubercle is recognized soon after the injury, open operation should be done, and the tubercle fixed in place by the single bone-nail.

4. **The shaft.**—Fracture of the shaft of the tibia unassociated with injury to the fibula is usually oblique or spiral in character and due to indirect violence caused by twists of the foot. It may also be caused by direct violence applied to the front of the shin bone. In

either case displacement is very slight, and its only important element is that of rotation resulting from the former type of injury.

Treatment.—The leg should be put up either on a back splint with side pieces or by means of a plaster case cut into two lateral halves. In either method it is essential that the splint be removed every day from about the third day onwards for massage and movements of the knee and ankle. While removing it, any tendency to recurrence of rotation deformity should be prevented by holding the foot by the toes.

5. **The lower end.**—Fractures of the lower end of the tibia apart from coincident injuries to the fibula are rare; they may, however, include separation of the internal malleolus (Wagstaffe's fracture) or of the lower epiphysis. Both these injuries are caused by powerful inversion of the foot, and their treatment is on the general lines described for fractures about the ankle-joint (p. 867).

THE FIBULA

Fractures of the shaft of the fibula apart from coincident injuries to the tibia are both uncommon and unimportant. The only two parts of the fibula which have any important function are the head at the upper end and the malleolus at the lower end. Any part of the bone may be broken by direct violence of a blow or gunshot wound. Fractures of the head and neck of the fibula are important because they may be associated with injury to the external popliteal nerve or rupture of the external lateral ligament of the knee-joint. Fractures of the lower part of the shaft of the fibula constitute a part of Pott's fracture, and will be considered with that injury (p. 867). Fractures of the fibula apart from injury to the external popliteal nerve or ankle-joint require no special treatment beyond massage and early movements.

TIBIA AND FIBULA

Fracture of these bones together is common in adults. (Plate 138, Fig 2) When it is due to indirect violence the bones give way at their weakest points, the tibia at the junction of its middle and lower third, the fibula at its upper end, the fracture of the tibia being spiral and that of the fibula oblique If it is due to direct violence, for example in a run-over accident, the bones give way at the same level, being broken more or less transversely, while the tibia is often comminuted. In both types of injury, displacement is frequently considerable. The oblique fractures show great overriding of the fragments, with marked rotation, while the transverse fractures have much lateral displacement. The skin is often damaged either by a sharp point of the tibia being driven through it or by the impact of the causative violence upon the shin. Great difficulty may be encountered in reducing the displacement owing to the powerful contractions of the calf muscles

causing interlocking of the fragments, and to the tendency, in the case of oblique or spiral fractures, for the sharp fragments to become entangled in the soft parts.

Treatment of these fractures depends upon the presence, character, and degree of the displacement. If this is inconsiderable and particularly if it is merely the slight lateral displacement of the fragments in a transverse fracture, no special treatment is required beyond that of resting the leg on a back splint provided with a foot-piece, slung up off the bed so as to flex the knee, side-pieces being added as an additional security. These are removed daily for massage, and after two or three weeks a divided plaster case may be substituted for the back splint and the patient allowed to walk with crutches. If the length and alinement of the tibia are restored, so that the bone is straight, particular care being taken that no posterior bowing is allowed to persist, and that the leg is not more than half an inch shorter than its fellow, there is no need for traction treatment, and still less for open operation. If great displacement exists, particularly when associated with comminution of the tibia, then treatment should be by weight-traction.

Much that has already been said about the general principles of treatment of fractures of the femur applies to fractures of the lower leg bones. Displacement can only be satisfactorily treated by traction. This may be applied as a single pull under an anæsthetic and maintained by fixation of the leg in a Thomas splint, a Macintyre splint, or plaster of paris But traction applied by a constantly acting weight in a mobile system, with the leg slung off the bed, is far more satisfactory. The application of the traction to the lower leg bones is, however, more difficult in one respect than in the case of the femur, because the portion of the limb below the fracture is comparatively small and therefore does not afford a good surface for the application [illegible] the foot [illegible] because [illegible] he tendo Achillis will quickly become sore if pressure is made upon it. Efficient traction in the case of the leg bones may therefore involve the use of a transfixion pin or calliper, which may be applied to the region of the malleoli or the posterior process of the os calcis. It is better to use the malleolar site for transfixion in cases of great displacement, high up in the shafts of the bones, in very muscular subjects, or in cases of old standing. In other cases, particularly when the fracture is at the lower end of the bone, the os calcis is the better site for transfixion. Traction on the os calcis has a double advantage over that on the malleoli, for pulling on the leg bones through the ligaments of the ankle-joint opens up the latter and prevents fixation of the ankle, while pulling in a line posterior to the ankle-joint directly overcomes the con-

contraction of the calf muscle and automatically prevents foot-drop When transfixion or calliper application has been made at either of the sites named, the leg is slung up to a cradle or overhead beam, or is laid upon the slings of a cradle splint (Fig. 852) which is of a somewhat shorter pattern than that used for the thigh. Counter-extension is provided by a sling under the flexed thigh, and also, when heavy weight is used, by a perineal band round the thigh of the injured side, tied to the head of the bed. The weight is attached to the pin or calliper—a horse-shoe grip being added in the former case—by means of a cord which passes over a pulley contained in the frame of the cradle splint, or attached to the foot of the bed if this splint is not used.

The weight required is 10 lb. in the case of a muscular limb, but considerably less in dealing with the leg bones of a young adult or a woman.

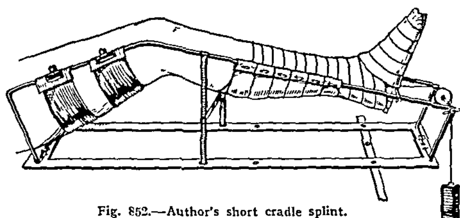


Fig. 852.—Author's short cradle splint.

The initial amount may be reduced by about one-third at the end of a week, and the weight-extension may be discontinued altogether at the end of three or four weeks. In addition to the adjustment of the traction, care must be taken of the position of the foot, the great toe being made to point forwards and a little outwards so that it is in line with the inner border of the patella. This position is secured by some form of foot-sling such as a piece of stockinet passed over the foot and secured to it by strapping or glue, the lower end being suspended to a point which will give the correct position of the foot. If the cradle splint is used the foot is bandaged to a shaped foot-piece, the position of which can be regulated by an adjustable cross-piece running on rollers.

After-care of these fractures is comparatively simple provided that primary good position has been obtained. After three or four weeks' traction the leg is fitted with a plaster case cut into two halves. Daily massage with movements of the joints, which should have been carried on during traction, is continued afterwards, and at the end of about five weeks the patient should be able to bear some weight on the

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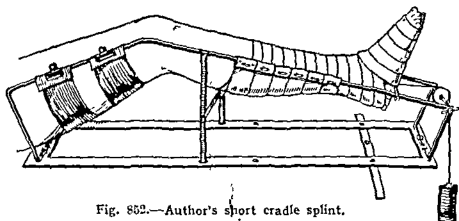


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After-care of these fractures is *comparatively simple* provided that primary good position has been obtained. After three or four weeks' traction the leg is fitted with a plaster case cut into two halves. Daily massage with movements of the joints, which should have been carried on during traction, is continued afterwards, and at the end of about five weeks the patient should be able to bear some weight on the

leg. It is not unusual for the fracture of the tibia to show evidence of non-union for several weeks later than the date named, but this need cause no anxiety, and it certainly should not lead to a further period of rest or splinting On the other hand, if the fracture is protected from injury by means of a plaster or felt case, or by side irons attached to the boot, the act of walking will more quickly restore the bone to strength and firmness than any other treatment.

Open operation for simple fractures was introduced primarily to meet the case of the fractures under consideration. It was justified in the case of fractures with much displacement when the only other resource was that of manipulation under an anæsthetic If the rule be now followed of not operating upon any case unless weight-traction applied in the manner above described has failed to reduce the deformity, there will be very few cases which will require operation. Moreover, the traction method in which the ankle and knee *are mobilized during treatment gives a much more rapid functional* recovery than that which attends plating operations. According to this view, open operation will be reserved for cases of gross displacement in which correct treatment has been unduly delayed, and for those rare cases in which displacement of recent origin cannot be corrected by traction.

Three types of operation may be practised. That most commonly done is the application of Lane's plate by means of short screws (Plate 138, Fig 3). Such a plate should not be applied to the subcutaneous surface of the tibia, if this can possibly be avoided, because it will cause pain and irritation to the overlying skin. It is better to apply it to the external surface of the tibia well behind the crest, where it will be snugly covered by the tibialis anticus muscle. In the case of a long, oblique, or spiral fracture the whole difficulty of the operation consists in accurately fitting together the displaced fragments. When this has been done the fracture is securely clamped by a suitable bone-holding forceps and two Parham bands or double wire circles applied round the bone near the two extremities of the fracture. A third type of operation, which is only suitable for transverse fractures without comminution, is the insertion of a short intramedullary bone peg. When the tibia has been firmly united by any of these methods it is quite unnecessary to do anything to the fibula.

Ununited fractures of the tibia should be treated by the insertion of a wide inlay graft taken from the other tibia, at least 6 in. long, $\frac{3}{4}$ in. wide, and of the full thickness of the tibial cortex. In gap fractures of the tibia it is sometimes better to do an oblique osteotomy of the fibula, so as to allow the tibial fragments to come into contact, but in addition to this it is usually necessary to remove the scar tissue from the tibial gap and to cut fresh surfaces to the tibial fragments.

FRACTURES AT AND ABOVE THE ANKLE-JOINT

reatment. There are seve... are due to direct violence, and
bones just above the ankle usually associated with considerable comminution. (2) **Pott's fracture** (Plate 138, Figs. 4, 5) consists in an oblique fracture of the fibula just above the tibio-fibular junction, associated with rupture of the internal lateral ligament or avulsion of the tip of the internal malleolus. It is caused by indirect violence wrenching the foot outwards, and is usually accompanied by much abduction with eversion of the foot and some displacement of the foot backwards. (3) **Dupuytren's fracture** (Plate 138, Figs. 6, 7) consists essentially in a rupture of the inferior tibio-fibular ligament, the astragalus being forced upwards between the two bones. It is often associated with some fracture of one or both malleoli. (4) **Wagstaffe's fracture** is the opposite of Pott's in that it is caused by an inversion of the foot which breaks off the tip of the internal malleolus and ruptures the external lateral ligament of the ankle.

Treatment.—Many of these fractures either present very little displacement, or the bones are easily replaced and kept in good position by any simple retentive splint. In these circumstances treatment should consist in the main of massage and mobilization carried out from the very outset. The retentive appliance used may [illegible] it should be [illegible] ment to be prevented, namely, backward displacement ... a whole, eversion or, more rarely, inversion of the foot, and foot-drop. One method of putting up ankle fractures is by the application of stockinet to the leg and foot, the upper end of this being attached by glue or strapping and the lower end being tied to a cradle above the leg in such a position as to produce dorsiflexion and the correct degree of inversion. The second method is to use a splint consisting of a side leg-piece and a foot-piece at right angles to it, the latter having a raised inner border so as to secure inversion. The third method is to put the leg and foot into a light plaster case, which is cut into two halves after its application. In applying such a case, care should be taken to hold the leg by the foot, the heel being pulled down while the toes are pushed up and the foot is inverted. There are several common mistakes in putting up ankle fractures. (1) In the application of plaster the limb is sometimes held up by supporting the calf of the leg, and thus the foot falls back as a whole, becomes plantar-flexed, and everted, exactly the three types of deformity which it is most

important to avoid. (2) The plaster case, instead of being cut open at once for daily massage and movements, is sometimes left in place for several weeks, leading inevitably to great stiffness of the ankle-joint, and, if the displacements mentioned have been allowed to persist, there will also be a severe grade of valgus deformity with flat-foot. (3) A back splint and foot-piece are used in such a way as to allow backward displacement of the foot and some degree of foot-drop; the displacement is caused by placing a pad underneath the lower part of the leg so as to prevent pressure upon the heel, thus pushing the leg bones forward and encouraging the foot to fall back. For the same reason, if the leg is raised from the back splint by the pad named, it will form an obtuse angle with the foot-piece instead of a right angle; that is, there will be foot-drop.

Ankle fractures with much displacement may be difficult to replace in anything like perfect anatomical position, but if they are dealt with at an early period there is no great difficulty in restoring them to such a position as will ensure good functional results. The best method of procedure is undoubtedly that of traction by means of a pin passed through the os calcis. This transfixion should be done towards the back of the posterior process of the calcaneum, so as to afford the greatest possible leverage in causing dorsiflexion of the foot. The foot is bandaged on to a foot-piece, and either slung from an overhead beam or fixed on to a cradle splint. The transfixion may usually be discontinued at the end of two or three weeks, when a plaster case made in two halves should be applied. The traction upon the foot by means of a transfixion pin gives complete command of the displacement in a way which is achieved by no other method. It has been suggested that, instead of transfixing the os calcis, a flat steel bar should be passed over the upper surface of its posterior process, in the interval between the tendo Achillis and the ankle-joint. This flat band is converted into a stirrup by joining its two ends to a cross-piece on which traction is made. But the use of this stirrup (Finochetto's or Shutro's) has little to recommend it, because it has no firm hold on the bone, and can therefore only be used for producing traction instead of being, like the pin, a handle for drawing forward the foot or correcting eversion. The use of the stirrup is also much more painful, as it tends to chafe against the soft tissues through which it is passed.

Fractures round the ankle-joint afford but little scope for *open operation*. Any displacement of the malleoli or of the foot can be much more efficiently dealt with on the lines already laid down. Operation should be confined, therefore, to one of two procedures. In Dupuytren's fracture, when the tibia and fibula have been broken away from one another, it will strengthen the ankle-joint and lead to more rapid consolidation if the two bones are bolted together, but this must be

done soon after the injury, before callus or fibrous tissue has filled the interval. The other operative indication is merely that of a removal of any loose fragments of bone which interfere with the free play of the ankle-joint.

After-care.—The patient should not be allowed to walk on the foot without adequate protection against developing flat-foot and valgoid deformity, both of which are likely to arise by stretching of weakened tendons and ligaments, and also as the result of bending at the line of fracture. The best and simplest safeguard consists in having the boot tilted outwards by a thickening of the inner margin of the sole and heel. Such a boot should be worn for at least three months after the patient begins to walk.

Malunited fractures of the ankle usually display a marked condition of flat-foot and talipes valgus. This may be due to the original deformity of eversion and abduction of the foot not having been fully corrected, or to the foot not having been properly supported during after-treatment. The only satisfactory treatment consists in osteotomy of one or both bones just above the ankle. The fibula may be divided by a simple osteotomy through the original line of fracture, if this be above the point indicated. A wedge-shaped piece should be removed from the inner aspect of the tibia, the angle of the wedge being the degree of correction. After the operation the leg and foot may be put up on a Thomas splint and foot-piece, the full degree of correction being maintained by appropriate bands; or plaster of paris may be used and kept in position for two or three weeks before being cut open.

THE TARSAL BONES

Injuries of the bones of the foot may present any degree of complexity, but the most common types of injury are those which result from indirect violence, such as falls upon the feet, in which case, as the foot forms an arch, the [illegible] —that is,

[illegible] is due to [illegible] the bone being broken at the neck, the astragalus driven downwards, and the arch of the foot abolished. Occasionally the posterior part of the os calcis may be broken off, when it will be drawn upwards by the action of the tendo Achillis. The treatment of cases with much flattening of the foot will require that this should be corrected [illegible]

and displaced upwards it should be fixed in correct position by means of a stout square bone-nail inserted through a posterior U-shaped incision

[illegible]

treatment or giving a prognosis. Mere fissures of the bone will not seriously affect the patient, though they may cause pain and weakness of the ankle for some time, but fractures with any [illegible] are likely to lead to serious disability, [illegible] the astragalus in the ankle-joint and [illegible] calcaneum below and the scaphoid in front. Two types of fracture may be distinguished; in one the head and neck of the bone are separated from the body, in the other the body of the astragalus is chipped or comminuted. The treatment of the simple cases should be by the most careful massage and mobilization, while that of the more complicated ones should be by open operation, with the removal of part or the whole of the broken bone.

Of the other tarsal bones, the **scaphoid** is the one most commonly injured. The injury m[illegible] [illegible]rcle when the foot is violently [illegible] when the foot is caught in th[illegible] [illegible]re seldom broken except by direct violence, and such fractures call for no special description.

THE METATARSALS

Th[illegible] [illegible] their shafts by direct violence, or [illegible] [illegible] may cause a painful swelling in the sole of the foot, and it should then be removed.

THE JOINTS

By C. C. CHOYCE, C.M.G., C.B.E., B.Sc., M.D., F.R.C.S.

INTRODUCTORY

For the classification and description of articulations the student must be referred to textbooks of anatomy, but he may be reminded that a joint is often a complex structure, and that description of its diseases involves consideration of many diverse tissues.

The bone-ends, especially the epiphyses and the para-epiphysial lines, are important factors not only in the anatomy but in the pathology of the joint, for not infrequently they are the primary focus of articular disease, as in some cases of tuberculosis and of acute arthritis. Cartilage—whether articular, epiphysial, or intra-articular—synovial membrane, and periarticular connective tissue may all play an important pathological rôle: so may ligaments, whether capsular and continuous with the periosteum of neighbouring bones; intra-articular, such as the ligamentum teres of the hip or the crucial ligaments of the knee; or accessory and often belonging to the morphological plane of the muscles, such as the long external lateral ligament of the knee. A bursa in many cases communicates with the neighbouring joint, and may be the initial site of the articular disease; the close connexion of many bursæ with the lymphatic system, and their liability to infection by a lymphangitic spread from a distant focus, must be remembered. The synovial membrane shows on its articular aspect many small villi which may become hypertrophied and cause symptoms of articular derangement. The synovial fringes of many joints, notably the knee, contain much fat which may in disease become so exaggerated as to form a so-called "lipoma arborescens."

The blood supply of most joints is rich and its anastomoses are free, in many cases forming a subsynovial circulus vasculosus. At the reflection of the synovial membrane, where the capsule becomes attached to the bone, there is a well-marked capillary anastomosis (circulus articuli vasculosus of William Hunter), and J. Fraser has experimentally shown the very important fact that lamp-black

injected into the vascular system tends to become deposited at this corner; for example, it collected on the lower aspect of the neck of the femur, at the synovial reflection of the knee near the epiphysial cartilage of the tibia, and around the astragalus, just in the places so frequently attacked by the tubercle bacillus.

The relation of the metaphysis (juxta- or para-epiphysial line) of the long bones (*see* p. 731) to the adjacent joint is an important one; in many cases (e g. the hip) it enters into the joint, the capsule being attached farther along the shaft. Obviously, therefore, disease beginning in the medulla of the cancellous tissue at this line may find an easy path into the articulation; as the metaphysis is in adolescence the part of the bone most likely to suffer strains, and is therefore most liable to disease, probably many cases of tuberculosis arthritis, and possibly of acute infective arthritis, have their origin there.

In connexion with the muscular atrophy often associated with prolonged articular disease, it is of interest to note that the nerves which serve the articulations also supply the overlying skin and the muscles that play over the joint; moreover, under the synovial membrane are many Paccinian end-bodies that may be concerned in receiving impulses from the normal movements of the joints, which return again in the form of trophic influences to the muscles of the part.

It seems clear that mere disuse does not sufficiently explain the wasting, often very rapidly progressive, that is associated with articular disease or injury; nor does the spread of infection from the joint into the muscles, for wasting involves the muscle in its whole length, and is not more advanced in the immediate neighbourhood of the joint. The muscles chiefly affected are the extensors (Ollivier, Gowers); thus, in the knee the quadriceps is most wasted, and in the shoulder the deltoid. The onset is generally synchronous with that of the arthritis, but very occasionally it has actually preceded the appearance of definite articular signs. It cannot be explained as being due to the interruption of a normal trophic reflex arc Experiments have been made by Raymond and by Hoffa, in which a pair of joints having been damaged so as to set up in them arthritis of equal degree, the corresponding posterior nerve-roots of one side were cut, those of the other side remaining uncut; the muscles on the side with intact reflex arc wasted rapidly, but those on the side on which the posterior nerve-roots had been divided showed little or no atrophy. Allen (1911) repeated these experiments and confirmed the results: he found that the muscle-fibres were reduced in size and more separated than is normal; the normal striations of the fibres were preserved, the muscle nuclei were not increased, and the nerve-endings showed no pathological change. The myotatic irritability of such atrophied

muscles is increased. The inference therefore is that the wasting is due to an active reflex effect, and is not trophic and passive. An important factor may be the tonic over-use of the muscles, in their effort, by spasm, to protect the joint from unexpected movement. In all cases of articular disease care should be taken to prevent muscular atrophy by gentle massage, if permissible, and even by some passive or, better, by guarded active movements, unless these are contra-indicated by other considerations.

Although many infective organisms, e.g. the gonococcus, prefer the periarticular tissues and are difficult to find inside the joint cavity, the synovial membrane resists pyococcal infection badly, thus differing from serous membranes such as the peritoneum. Therefore in all open wounds, operative or accidental, of a joint the most rigidly aseptic precautions are obligatory. In operating, the skin must be prepared with exceptional caution, the wound edges kept covered (with cloths) to obviate the possible transference of organisms from the skin into the joint, and all intra-articular manipulations made with instruments and not with the fingers.

The epiphysial cartilage, being dense in structure and avascular, is often a barrier to the spread of disease. For instance, spread of sarcoma of the diaphysis is usually limited by this layer, and acute staphylococcal infection prefers to spread down the medullary canal of the bone rather than to perforate the epiphysial cartilage As already mentioned, however, the fact that many epiphysial junctions are intra-articular may permit infection of the joint.

As regards the repair of articular cartilage, recent experiments by Timbrell Fisher show that wounds near the periphery of an articular cartilage, i e near the vascular synovial fringe, may be partly repaired by actual re-formation of cartilage; near the centre, however, a cut is repaired with fibrous tissue unless the incision is deep enough to reach underlying cancellous bone; in such case some true cartilage repair occurs. Articular cartilage probably obtains nourishment from the following sources: (a) from the circulus vasculosus to the peripheral part of the cartilage, (b) from the underlying cancellous bone to the deeper strata of the central portion, and (c) from the synovial fluid of the joint to the superficial strata of the central portion Strangeways has shown that a completely "loose body" of cartilage can live and enlarge; in this case, however, it is open to argument that, the joint being damaged by the pressure of the loose body, the synovia contains more albuminous material than is normal. Fisher, using the method of staining mucin with carbol-thionin, finds tracks around cell groups and through articular cartilage in which the mucin is probably less dense than elsewhere, and suggests that these indicate the paths by which nutrient fluids reach the cartilage cells.

MASSAGE AND MOVEMENT IN TREATMENT

Massage, properly applied, is a therapeutic measure of great value in many articular lesions, and one too *often neglected.* In the treatment of fractures into joints, of adhesions, of synovial effusion, and for the prevention of muscular atrophy associated with chronic arthritides, it is of paramount importance. In active tuberculosis and other conditions demanding rest as their essential treatment it is contra-indicated, or must be used with caution. It is impossible here to enter into details of the different forms of massage and their application to individual joints and diseases; it must suffice to mention the chief varieties, namely:—

1. *Effleurage,* a series of upward stroking movements, designed to relieve pain and to promote the absorption and removal of superficial exudates. *The stroking movements should be evenly made,* the hand being more lightly kept in contact with the limb during the return sweep; a rotary action is often of value. The masseur's hand should be dry; if it tends to sweat it may be dusted with an impalpable inert powder. Massage should be commenced and finished in all cases with light effleurage, beginning above the level of the affected joint.

2. *Pétrissage* or *kneading* may be applied in different ways, and is especially applicable to stimulate muscles and to promote removal of effete products along intermuscular planes, lymphatics, and veins. The part may *be kneaded between the masseur's two hands, between his palm and fingers,* or between his hand and underlying bone. The operator should commence work above the joint and, always making the heavier stroke in an upward direction, should gradually come down the limb.

3. *Tapotement,* a rapid flipping, flicking, or tapping movement, is less frequently necessary in joint surgery.

4. *Passive movements* of the affected joint, and of the joints above and below, are in many cases, especially of stiffened joints, of great importance. Each individual articulation should be put through its range of movements separately. *It should be the masseur's aim to secure a maximum* of movement with a minimum of discomfort to the patient and of subsequent synovial effusion; the presence of great and painful effusion after massage is often a sign that the movements have been too violent and that perhaps harm has been done.

5. *Active movements* are of even greater value for retaining muscular tone, but may not be permissible if muscles or tendons are damaged. Gentle active movements against graduated resistance applied by the surgeon are to be used before any weight-bearing or strenuous ones are allowed.

EFFUSION

The normal balance between secretion and absorption of synovial fluid is readily disturbed; this leads to exudation into the articular cavity. Inflamed or injured surfaces are thus separated, the part loses its normal contour, hollows are filled up, and the joint is held rigidly in the position of greatest ease, i.e. that in which it contains *most fluid at lowest tension.* An extreme degree of effusion, long

continued, may so stretch the already damaged capsule and ligaments that the joint remains permanently weakened, and therefore subject to further strains and to recurrences or exacerbations of effusion. In such a case the fluid should be aspirated to relieve the pressure.

The signs of intra-articular effusion vary with the articulation affected. In all cases the joint is held in the position of greatest ease. This position varies with the joint affected: thus, the shoulder tends to be held either adducted or in a position of slight abduction and with the elbow slightly forward and supported upon the other hand; the elbow is kept at an angle of about 110°, with the forearm midway between pronation and supination; the hip is flexed, abducted, and externally rotated, and the knee flexed to about 45°.

Movements are limited to a degree varying with the amount of effusion and with the character and amount of the concomitant disease or injury of the component structures of the joint.

In the *shoulder* the deltoid is raised and a soft swelling is obvious at its anterior border; sometimes also at its posterior edge and in the axilla Both active and passive movements are painful, and the joint is held rigidly still. A subdeltoid bursitis causes similar expansion of the deltoid, but in this case gentle passive movements, especially rotary ones, may be painless, and the swelling at the deltoid edges and in the axilla are absent. Synovial effusion into the *elbow* fills up the grooves on either side of the triceps tendon and of the olecranon, especially on its outer aspect; sometimes it also causes tumidity in front of the joint. Olecranon bursitis, on the other hand, produces a fluid swelling over the bone itself; in it, moreover, passive movements of the joint usually are comparatively painless. Effusion into the *wrist* causes an annular cystic swelling, deep to the tendons and most marked anteriorly and posteriorly. The movements of the fingers and thumbs are free, and cause no palpable crepitus such as that characteristic of teno-synovitis. Effusion into the *hip* is not easily observed, though it may cause slight tumidity in Scarpia's triangle or in the buttock; limitation of movements and the adoption of the position of greatest ease is marked. Distension of the *knee* obliterates the hollows on either side of the patella and its ligament, and fills up the subcrureal bursa; the joint therefore looks rounded and swollen. The patella is readily felt floating in front of the effusion, and in well-marked cases can be made to "tap" against the femur. In less exaggerated cases the presence of effusion is best elicited by extending the knee with the limb dependent and muscles relaxed, and, after pressing with one hand downwards above the patella, feeling for fluctuation with a finger and thumb on opposite sides of the ligamentum patellæ Effusion into

the *ankle* fills up the hollows behind the malleoli, and also raises the tendons on the dorsum.

The *treatment* involves the specific treatment of the underlying cause. The symptom itself should be dealt with on the lines laid down at pp. 884, 978.

ANKYLOSIS

Ankylosis, or immobilization of joints, may be due to osseous or fibrous changes in the articular structures (true ankylosis), or in extra-articular structures such as muscles, skin, etc. (false ankylosis) The *latter may be caused by cicatrization, by muscular contractures*, or by ossification as in myositis ossificans.

Fibrous true ankylosis may result from the formation of intra-articular adhesions associated with tuberculosis, gonorrhœal or other infective arthritis, rheumatism, injury to intra-articular ligaments, or erosion of articular cartilage. *It usually permits a certain range* of movement, and not infrequently the patient is on the alert to prevent over-free passive movement. In *osseous true ankylosis*, on the other hand, the patient will frequently regard with indifference the surgeon's attempts at movement. The union in these cases is due to the ossification of fibrous adhesions when associated with erosion of cartilage; in other cases a rough dovetailing (and, occasionally, fusion) of osteophytes, such as those seen in Charcot's disease and in osteo-arthritis, produces a condition of pseudo-ankylosis.

An *adhesion* is a minor degree of fibrous ankylosis, one still capable of being broken down by a series of gradually increasing manipulations, or by more forcible methods under anæsthesia.

Causes.—Articular ankylosis may be due to—

(*a*) Arthritis of any form which results in fibrous adhesions or in contraction of capsular and intra-articular ligaments.

(*b*) Suppurative arthritis, due to the pyogenetic organisms, and involving damage to cartilage and subjacent bone.

(*c*) Tuberculosis, especially if secondary infection with pyogenetic micro-organisms has occurred.

(*d*) Fractures into the joint. In this case the union may be complete if both constituent bones have been damaged; or incomplete if the disability be due to jamming by displaced fragments or by callus, or to organization of effused blood.

(*e*) The long-continued retention of a slightly injured joint in a constrained attitude may lead to the development of strong adhesions. This especially occurs in the knee when the limb has been extended for some weeks for the treatment of fracture of the femur, without very obvious involvement of the joint itself.

(*f*) Neurotrophic influences, as in tabes, syringo-myelia, spina bifida or in neuritis, whether due to nerve injury, to leprosy, diabetes or other cause, may occasionally lead to a chronic arthritis and so induce ankylosis.

During the treatment of any articular disease it is all-important to prevent adhesions by massage, passive and active movements, or other means permitted by the state of the joint. If it becomes obvious that ankylosis must be allowed to occur—for example, in tuberculosis—every care must be taken to ensure fixation in a position that will involve the least subsequent disability. In the case of the *shoulder* the freedom of movement permitted between scapula and thorax overcomes much of the disadvantage, and the joint may, if necessary, be allowed to become rigid with the arm abducted about 20°–30° from the trunk, and the elbow a little in front of the coronal plane of the body; this position allows free range of the thoracico-scapular movements, avoids axillary intertrigo, and permits ready cleansing of the axilla. The *elbow* should be fixed with the forearm fully supinated, and the angle of fixation at the elbow should be such that the patient can reach his collar-stud and his mouth; an angle of 90° or a little less is therefore best. If the patient proposes to earn his living by writing, the position midway between pronation and supination is justifiable, but for most purposes full supination is best, because pronation can be obtained by free rotation at the shoulder and thoracico-scapular joints. In the *hip* any approach to inversion and adduction should be avoided. The *knee* should be allowed to ankylose with about 5° of flexion, in order that in walking the foot may just clear the floor; but after excision this factor need not be considered, as bone has been removed and the limb shortened; in this case the limb should be straight, without either flexion or recurvation. In the *ankle* the foot must be at right angles to the leg.

Treatment of adhesions and ankylosis.—If the condition of the joint permits massage and movements, adhesions should be prevented. It is often necessary, however, to await quiescence of the disease, and then to break down the bands. If there is danger of recrudescence of the tuberculous or other causative disease it is wisest to be content to leave the ankylosis alone. This is also true where the adhesions are massive and where even comparatively gentle attempts to rupture them are persistently followed by acute synovitis. Such adhesions may be so strong that the neighbouring bone will fracture before they give way. In breaking down adhesions it is advisable to perform a series of gradually increasing manipulations, or to apply gradual extension in the long axis of the distal segment or just out of it Each manipulation should be preceded and followed by massage, and an endeavour made to avoid much painful synovial effusion; this plan is preferable to any attempt forcibly to move the joint under anæsthesia. In some cases, however, such forcible procedure must be used at the beginning of the treatment. When ankylosis is well established, and it has been

decided that the deformity or the disability and the freedom from *active disease justify surgical* interference, operation is necessary. If the bones have ankylosed in the position of election the shoulder, wrist, and ankle are best left alone, but if necessary the shoulder may be excised; in such cases the operation is often difficult and the after-treatment troublesome. Excision of the elbow gives good results and a movable new hinge-joint, especially if the excision be converted into an arthroplasty by the insertion of a flap of fascia derived from the fascia of the arm, or of a free sheet of fascia lata from the leg (McCausland). In the case of a badly placed hip the anterior surface of the neck may be exposed, and the neck sawn across with an Adams or a chain saw; the bone is then reset in a better position and allowed to unite. If skiagraphy shows a wasted, thin femoral cervix, Gant's subtrochanteric osteotomy is preferable. A better operation is Murphy's arthroplasty for the formation of a new false joint; to re-establish movement he turned in a flap of soft tissues, chiefly fat and fascia, to prevent reunion. It works well in many cases, but in the hip the flap of skin replaced is very thin and in danger of giving way.

If the knee is ankylosed in faulty position, Murphy's operation may be adopted; or the surgeon may be content with removing a wedge-shaped piece of bone and allowing reunion in the improved position.

BAKER'S CYSTS

These cysts, first described by Morrant Baker, are cystic swellings originating as herniations of synovial membrane through gaps in the capsular ligaments. They are caused by any articular condition which at the same time raises intra-articular pressure and weakens the capsule; they are therefore seen in connexion with chronic disease, especially *tuberculosis* and osteo-arthritis They are not infrequently multiple, and are commonest in connexion with the knee. At first in wide communication with the joint cavity, a Baker's cyst tends to travel downwards between the tissues of the limb, probably through the action of gravity, until finally it may reach a position far from the joint of origin, to which it remains connected only by a thin pedicle with a more or less obliterated lumen.

Treatment should be directed towards the etiological articular affection. The cyst itself, if causing discomfort or disability, may *with the* usual rigidly aseptic precautions be excised, with its pedicle, the opening into the joint being closed by suture or, if narrow, by a ligature. If causing no symptoms, the cyst should be ignored, and all attention given to the underlying disease, which in many cases is tuberculous. In most of the specimens upon which Morrant Baker founded his description the joints have upon re-examination proved to be tuberculous (Gask and Wilson).

HYDRARTHROSIS, OR HYDROPS ARTICULI

These terms are frequently used to denote a persistent effusion into a joint; it is a symptom in many chronic articular diseases such as some forms

of osteo-arthritis, secondary syphilis, neuropathic arthritides, or chronic serous arthritis (synovitis). Its signs are those of chronic effusion; its treatment is that of the etiological disease; in some cases its persistence and the degree of distension call for aspiration.

Intermittent hydrarthrosis is a phenomenon of obscure etiology in which there is a recurrent effusion into a joint or joints at intervals that are often of exact periodicity.

Etiology and pathology.—The age of onset is anywhere between 10 and 40; both sexes are affected, the female rather more frequently than the male. The relationship to female reproductive phenomena is obscure, but it has been stated that an attack coincident with a menstrual period is exceptionally severe, and that in some cases the attacks have temporarily ceased during pregnancy.

The affected joint in many cases appears normal during the intermission; in others there are signs of definite chronic disease such as rheumatoid arthritis, gonorrhœal rheumatism, or staphylococcic chronic osteo-myelitis. Trauma occasionally initiates the first attack.

The condition has been associated with epilepsy, exophthalmic goitre, urticaria, and giant urticaria; polyuria and dysuria have been found during the period of effusion. It has been held to be a form of angioneurotic œdema, but its true pathogeny is unknown. It is difficult to ascribe its exact periodicity to any known organism. The fluid is sterile.

Clinical features.—At exact periods, constant for the individual patient, the joint (usually the knee) suddenly and without warning becomes distended with fluid. Except in rare cases there is no redness or heat. After about three or four days the effusion disappears and is absent until the appointed time for the next attack. As a rule the hydrarthrosis causes more inconvenience than pain, though in rare cases the latter is a prominent feature.

The cycle between the commencement of one attack and of the next is extremely variable in different patients; the average is said by Beuda to be from eight to eleven days. The duration of the effusion is three or four days in most cases, but may be as long as three weeks.

Prognosis.—Intermissions may occur during pregnancy or at any other time; when, as is usual, recurrence takes place, a new cycle may be established.

Spontaneous cure may occur, or the condition may persist for years.

Treatment.—Cures or improvement have been claimed for the internal administration of arsenic or quinine, for electrical treatment, and for injection with iodine. Possibly ionic medication would prove of value. Rest, strapping, etc., are useless.

HÆMARTHROSIS

The causes of effusion of blood into joints fall under the following headings:—

1. Traumatic, often associated with fracture involving the joint.
2. Hæmophilic (*see* p. 880).
3. Scorbutic, in the course of scurvy and of allied hæmorrhagic diseases.
4. Tuberculous. A few rare cases have been recorded (Mauclaire, Lejars).
5. Neoplastic, in association with sarcoma and other neoplasms.

6. Neuropathic. A few cases have been recorded in tabes, syringomyelia, and transverse myelitis.

Of these, all except the first two are very rare. The discussion of traumatic hæmarthrosis is included under Sprains (p. 977).

HÆMOPHILIC JOINT DISEASE

In hæmophilia (*see* Vol. I., p. 342) any slight blow or strain may cause hæmarthrosis. The articular cavity rapidly fills with blood; although the associated pain may be slight, the joint is somewhat warmer and more tender than its fellow, and is stiff and painful in movement. The intra-articular effusion at first presents the usual physical signs (*see* p. 875), but soon feels firmer than an ordinary serous exudate. Sometimes staining of the superficial tissues with blood pigments follows, and intra-articular crepitation may be palpable. The knee (Plate 139) is the commonest victim, but the elbow, ankle, hip, shoulder, or wrist may be affected in that order.

The hæmarthrosis may follow one of several courses:—

(*a*) Complete recovery may ensue after absorption of the whole effusion.

(*b*) Absorption may occur, but the joint may remain weak and subject to future attacks.

(*c*) Adhesions may develop, perhaps sufficiently strong to immobilize the joint completely; adequate measures must therefore be adopted to maintain the limb in a useful attitude during recovery.

(*d*) Changes very similar to those seen in osteo-arthritis may ensue. The articular cartilages, though retaining their original colour, show fibrillation of the matrix, roughening and erosion at points of pressure, and ecchondroses at their edges. The bone ends atrophy, but develop marginal osteophytic outgrowths. The ligaments and synovial membrane may be greatly stretched, are stained with blood pigments, and are often, though not always, thickened and lined with a brown fibrinous coat. Intra-articular loose bodies have been observed.

The **prognosis** is always serious, though death does not usually result from the hæmarthrosis itself, unless the surgeon interferes. The danger of future hæmorrhages, of ankylosis in faulty position, and of pseudo-osteo-arthritic changes must be remembered. Many hæmophilics die in youth; if they survive the age of 25 the manifestations of the disease often become less marked.

Treatment.—It is all-important that operative interference, even puncture, should be avoided; many cases surgically treated have died. The limb should be put at rest in a position suitable for future use in the event of ankylosis occurring. The patient should be kept quiet, by the internal administration of morphia if necessary, and the affected joint gently and watchfully compressed by means of a moderately firm bandage over a thick layer of cotton-wool. The local use of ice or of evaporating lotions is sometimes useful. Later, absorption may be promoted by the application of mercurial ointment, by gentle pressure with a Martin's india-rubber bandage, and by careful massage. To promote coagulation, calcium lactate may be given internally in relatively large doses (10 gr. or more thrice daily), or Weil's plan of injecting 10–20 c.c. of *fresh* blood serum, repeated in two days, may be adopted. Rugh recorded good results from the exhibition of thyroid extract (5 gr. t.d.s.). Transfusion with a compatible blood is sometimes of value in promoting coagulation and replacing lost blood.



Hæmophilic knee.
(*From Marsh and Watson's "Diseases of the Joints and Spine"*)

PLATE 139.

SYNOVITIS

Very rarely, if ever, does the synovial membrane suffer alone: recurrent or chronic "synovitis" is practically always associated with injury or disease of ligaments, cartilages, or bones, and the condition is really one of non-suppurative arthritis. The chief clinical manifestation is a synovial effusion, the characteristics of which are discussed at p. 871. The disease "synovitis" does not really exist alone, and the cases usually diagnosed as such should be classed either with injury or with arthritis.

ARTHRITIS

This term covers a very wide field: it includes any articular disease in which the morbid anatomy is indistinguishable from that usually seen in inflammatory disease elsewhere. "Chronic arthritis," especially, must be made elastic, for the pathological changes are often indistinguishable in diseases clinically so distinct as tuberculosis, syphilis, neuropathic arthropathy, rheumatoid arthritis (including the undoubtedly chronic infective cases as well as those in which an infective or toxic cause can only be assumed).

The etiology may be infective or toxic, neurotrophic, or traumatic.

The clinical features vary within wide limits with (1) the relative acuteness of the condition and (2) its cause.

The changes seen in arthritis are present in cases that may be classified under the following headings:—

I. **Traumatic.** *See* Sprains, p. 977.
 „ Internal Derangement, p. 1006.

II. **Infective** (or toxic), including cases due to circulation of toxins as well as those resulting from direct microbial infection.

1. Non-suppurative.

Examples:

(*a*) The synovial intra-articular effusion sometimes associated with neighbouring bony, bursal, or cellulitic inflammation.
(*b*) Many cases of rheumatoid arthritis and possibly of osteo-arthritis (*see* pp. 947, 957)
(*c*) Rheumatism (*see* medical textbooks).
(*d*) Gout (*see* medical textbooks).
(*e*) Syphilitic arthritis (*see* p. 913).
(*f*) Gonorrhœal rheumatism (*see* p. 889).
(*g*) Some types of pneumococcal arthritis (*see* p. 887).
(*h*) Dysenteric arthritis (*see* p. 895).
(*i*) The arthritides sometimes associated with zymotic disease.

2. Suppurative.

Examples:

(*a*) Due to ordinary pyogenetic organisms, e g. staphylococci, streptococci, bacillus pyocyaneus, etc.

(i.) *Pyæmic.*

(ii.) Direct infection from a wound or neighbouring focus of suppuration.

(*b*) Some cases of gonorrhœal arthritis (*see* p. 889).

(*c*) Many cases of pneumococcal arthritis (*see* p 887).

(*d*) Tuberculosis of joints (*see* p. 896) Necrotic débris rather than true pus, unless double infection has occurred.

III. **Neurotrophic,** as in tabes, syringo-myelia, etc. (pp. 970, 975)

IV. **Subacute and chronic non-suppurative arthritis of doubtful cause,** such as the painless synovial effusions (non-syphilitic) sometimes seen in the knee-joints of young girls at puberty.

Morbid anatomy.—In all these varieties the morbid anatomy is essentially similar, though in some of them certain features predominate. Thus, the character of pus in a staphylococcal case usually differs somewhat from that of a pneumococcal arthritis; caries is more prominent in tuberculosis than in many other varieties of chronic arthritis; in osteo-arthritis the proliferative and hypertrophic element dominates the destructive, whilst in rheumatoid arthritis or in the atrophic variety of neuropathy, atrophy is in excess.

In **acute non-suppurative arthritis,** such as that seen in traumatic "synovitis," the synovial membrane is hyperæmic and is thickened and softened owing to serous exudation and leucocytic extravasation into it; there is always some proliferation of fixed connective-tissue cells The ligaments may be torn, and may also show exudation of fluid and extravasation of blood cells The endothelial lining of the joint proliferates, and cells are shed from it. The joint becomes filled with a serous exudate which contains some shed endothelial cells, some leucocytes, and often fibrinous filaments. This effusion in most cases is absorbed; but sometimes, especially when ligaments have been weakened by the size of the effusion or by the initial injury, and thus predisposed to further strains, the effusion may remain chronically excessive, or after absorption may repeatedly recur. In other cases the effusion may dry up, but organized adhesions may follow.

In **acute suppurative arthritis** very serious and extensive changes occur.

Pyogenetic infection may be caused by—(1) the direct entrance of organisms such as staphylococci, streptococci, bacillus pyocyaneus, etc, through an open wound into the joint; (2) by spread from a neighbouring osteo-myelitis, epiphysitis, bursitis, or cellulitis; (3)

by auto-infection with pneumococci, staphylococci, streptococci, etc., from a distant focus such as the throat, ears, or lungs; (4) by double infection with blood-borne organisms of a joint already affected with rheumatism or gonorrhœal rheumatism; (5) by infection of a neuropathic joint from a perforating ulcer or whitlow in its neighbourhood (e g. in syringo-myelia); or (6) occasionally by direct pyogenetic action of the gonococcus.

The synovial membrane becomes red and juicy; the extravasated and proliferated cells degenerate and suppuration occurs, the membrane being converted into suppurating granulation tissue. That part of the synovial membrane that overlaps the edges of the articular cartilages (the "veil of Billroth") becomes a "pannus" of granulation tissue which assists in the erosion of the articular cartilage. The articular and intra-articular cartilages become yellow and lustreless, and are eroded not only by the ingrowing "pannus," but by the pressure between bones, and, after perforation, by being lifted from the underlying bone by ingrowing granulation tissue; they therefore undergo necrosis and absorption. The bone-ends suffer from rarefying osteitis. The periosteum is inflamed; later, new subperiosteal bone and peripheral bone may be thrown out and osteophytic projections develop.

The ligaments are œdematous, infiltrated, and relaxed. Neighbouring muscles are atrophic and often in a state of contracture.

The intra-articular effusion, at first only turbid, soon becomes purulent; eventually it may burst through the capsule and travel far along the intermuscular planes.

Chronic arthritis.—The pathology of tuberculous chronic arthritis is discussed at p 900. That of the non-tuberculous varieties of chronic arthritis is more indeterminate; unfortunately the pathological types cannot be made to correspond exactly to the clinical types, and very similar morbid changes are found in clinically distinct diseases Nichols, therefore, divided the anatomical lesions in chronic arthritis into five types, viz the serous, ulcerative, ankylosing, formative, and fungous varieties

The principal elements are (1) effusion; (2) atrophy and erosion of cartilage, exposure, atrophy, and superficial eburnation of underlying bone; (3) plastic changes: cartilage destruction, organization of the granulation tissue "pannus," and development of strong adhesions, which may become ossified; (4) new osteophytic outgrowths; (5) hypertrophy of synovial villi and fringes, which may become loaded with fat (lipoma arborescens). These elements are to be found mixed in different proportions in the various clinical varieties of chronic arthritis. Thus, effusion may be associated with one or several of the other elements; plastic changes are combined with ulceration,

and so on (*See also* under Rheumatoid Arthritis (p. 947), Osteo-Arthritis (p. 957), and the other varieties of chronic arthritis.)

TRAUMATIC NON-SUPPURATIVE ARTHRITIS

This form of arthritis occurs when the joint is injured, whether by a blow or a wrench The morbid anatomy is described above (Acute Non-Suppurative Arthritis, p. 882). Complete resolution may occur, or the condition may develop into a chronic (or subacute) arthritis of the serous or of the plastic (ankylosing) type.



Fig. 853 —Septic arthritis of the knee, following a compound fracture of the lower end of the femur involving the joint.

(*Dreadnought Hospital Museum, Greenwich*)

Traumatic arthritis may be associated with a dislocation, a fracture involving the joint, a sprain, or an internal derangement, or may simply consist of a traumatic "synovitis."

The **treatment** adopted must be that for effusion, combined with that of the associated fracture, dislocation, or other gross lesion. Rest, cooling lotions, and elastic pressure should be used at first, and followed by massage and passive movements. The latter should be very gentle till effusion has disappeared. If the effusion evinces a tendency to become chronic, counter-irritation with pigmentum iodi, with blisters, or with the actual button cautery, or the combination of rest, counter-irritation, and pressure obtained by the use of a *Scott's*

dressing, is useful. *Scott's dressing* consists of unguentum hydrargyri camphoratum (co) spread on strips of lint, which are evenly applied around the diseased joint. Over them strips of strapping plaster are firmly and evenly fixed, each overlapping about half of its predecessor. The dressing loses much of its value when loose, and requires reposition every third day. It combines the principles of pressure, splinting, and counter-irritation, and is of great value in many subacute and chronic arthritides, especially if there be much effusion. Cold douches are sometimes of value, but should not be used in feeble old patients

ACUTE SUPPURATIVE ARTHRITIS

This may arise in any of the ways mentioned above (p. 882). It may be preceded by a serous effusion and other evidences of a non-suppurative arthritis. For the morbid anatomy *see* p. 883 and Fig. 853.

Clinical features.—The onset of pyarthrosis due to one of the ordinary pyogenetic organisms is marked by general malaise, fever, and in severe cases by rigors and signs of an acute toxæmia.

The joint becomes hot, very tender, and intensely painful; it is distended with fluid, and is held rigidly at rest in the position of greatest ease, usually semiflexed. The muscles are contracted, and in the later stages the surrounding parts become œdematous. Unless relieved by the surgeon, the intra-articular tension increases, ligaments are greatly stretched, cartilage is eroded and destroyed, and neighbouring cancellous bone infected. Eventually the ligaments give way and the pus tracks widely along the intramuscular planes. Destruction of the joint may progress to such an extent that abnormal movements and dislocation may occur. The escaped pus finds its way to the surface and through the skin; sinuses then open in all directions.

When the suppurative arthritis is a secondary embolic process arising during the course of pyæmia the affected joint rapidly fills with pus, sometimes so painlessly that the patient does not attract attention to the condition; careful personal watch, therefore, must be kept by the surgeon, in order to discover and treat the arthritis as soon as possible; if the joint be washed out at an early date and the patient's vitality be good, a favourable prognosis can often be given as to the fate of the joint; but if recognition and treatment of the arthritis be delayed, disorganization will quietly occur.

Prognosis.—The condition is one involving great danger to life. Pyæmia, if not already present, may commence at any time. The patient is exhausted by the pain and sleeplessness and overwhelmed by the toxins. Unless the surgeon intervenes, death frequently occurs either as a result of acute toxæmia, of pyæmia, or of exhaustion; or if the patient survives until the pus discharges itself, he still

runs a grave risk of continued suppuration ending in amyloid disease and death.

Even if efficient surgical treatment has been adopted, the outlook as regards restoration of articular function is often gloomy; usually the surgeon must be content with ankylosis, taking care that it occurs in a useful position.

Treatment.—If the condition be seen before suppuration has actively commenced, the limb should be placed at rest in a useful position, and an attempt made, by fomentations, Bier's bandaging, internal administration of calomel, and general treatment, to abort the attack. If any doubt exist in the surgeon's mind as to whether suppuration has commenced, he should aspirate. If, however, suppuration has occurred, the joint must be freely opened (by multiple incisions if necessary), washed out with some antiseptic lotion followed by saline solution, and drained. Hydrogen peroxide (10 volumes), or biniodide of mercury (1 : 5,000), followed by copious lavage with saline, may be used The subsequent treatment should be by Carrel's method of instillation with Dakin's solution (Vol. I., p. 282), followed by closure when the bacteriological findings justify this procedure. If the infection be recent and the damage to joint structures not yet well developed, it may be possible, by the use of flavine packs for forty-eight hours, to get the joint clean enough to permit of suture then ; this method, if successful, may leave a mobile and useful joint.

In severe cases the use of continuous irrigation with warm water or eusol or weak iodine solutions through the thoroughly opened joint is advisable ; or the patient may with advantage be nursed in a large warm bath of equable temperature.

Diet should be nourishing but easily digestible, and the bowels regulated, a mild mercurial laxative being administered daily if necessary.

Occasionally articular movement is recovered, but usually ankylosis occurs.

As a rule immobilization of the affected joint during treatment is advisable, but Willems has introduced for acute arthritis due to Streptococcus hæmolyticus the method of allowing active movements after the joint has been opened ; the muscular and articular movements help to empty the synovial pockets, hasten cleansing of the joint, and encourage the retention of mobility ; this method is sometimes very successful, but the general condition of the patient may prevent its continuance.

If the patient does not rapidly improve after drainage, and is in danger of death, the limb must be amputated.

Excision may sometimes be necessary after all active disease has long been abolished, to overcome ankylosis in faulty position, to secure

a new movable joint (e g. in the elbow), or occasionally to remove a chronically arthritic joint with persistent sinuses.

The thoroughness with which the affected joint is opened greatly affects the prognosis; one incision rarely suffices. The *knee* is a compound joint with several synovial pouches and cannot be adequately opened through any simple incision. Barnard recommended five incisions, viz. a wide one on each side of the patella, the external incision being extended 3 in. upwards so as to open the whole subcrureal pouch; in addition, an incision should be made behind each femoral condyle, and another, if necessary, through the outer part of the posterior ligament just internally to the biceps tendon; the external popliteal nerve must be preserved. But even this is often inadequate, and, if the whole joint appears to be involved, it is better to make a bold horseshoe-shaped incision across and through the ligamentum patellæ, and so, by turning up the patella and flexing the knee, to open the joint widely; later the ligamentum patellæ may be sutured.

The *hip* should be opened anteriorly or posteriorly, or both. Acute suppurative arthritis here frequently results from osteo-myelitis of the femoral neck, which may later form a sequestrum requiring removal.

The *ankle* should be opened at the front and both sides. Drainage is often not free unless the astragalus is removed.

The *shoulder* should be incised anteriorly and a counter-opening made posteriorly.

In the *elbow* free incisions must be made on both sides of the olecranon, with care to guard the ulnar nerve After ankylosis has occurred and the disease is entirely gone, excision to secure a new joint is of advantage. In children this procedure should be deferred until the growth in length of the bones is complete, at about the twentieth year.

The *wrist* should be opened by several dorsal and lateral incisions made parallel to the tendons and avoiding the tendon sheaths.

PNEUMOCOCCAL ARTHRITIS

This form of arthritis may be secondary to pneumonia, or may be "primary." This term is, however, inaccurate in that it assumes the articular site to be the initial pneumococcal deposit. Such primary cases occur chiefly in children, and are practically always a pyæmic manifestation dependent on the presence of the pneumococcus carried in the blood-stream from a distant focus. In adults the arthritis is usually associated with definite pneumonia. The disease varies greatly in severity from a mild localized arthritis to a fatal pneumococcal septicæmia.

Etiology.—The pneumococcus is borne to the joint by the blood-stream from the lungs, tonsils, pharynx, or ears. In children the arthritis may occur during one of the exanthemata. Its incidence decreases as age

runs a grave risk *of continued suppuration ending in amyloid disease* and death.

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Etiology.—The pneumococcus is borne to the joint by the blood-stream from the lungs, tonsils, pharynx, or ears. In children the arthritis may occur during one of the exanthemata. Its incidence decreases as age

increases; during infancy the pneumococcus is by far the commonest cause of acute arthritis. The two sexes are equally affected; in this, therefore, it differs from pneumococcal peritonitis, in which there is a preponderance of female cases. Injury may determine the lodgment of the organism in a given joint, but in many cases no history of trauma is obtained.

Morbid anatomy.—The inflammatory changes are often confined to one joint, usually a large one such as the shoulder or the knee, and vary greatly in degree with the clinical type. In the milder cases they affect the synovial membrane chiefly, but in the more severe examples the periarticular tissues may show considerable extravasation and effusion, and the cartilages and bones may be eroded and inflamed. The contents of the joint are generally thick and purulent, but occasionally are sero-purulent or even serous. The pus is quite odourless; it sometimes shows a slight greenish tinge.

Clinical appearances. The appearance of the joint varies. Sometimes ... ied, and the chief evidence of ... redness, swelling, and heat may be marked, and the periarticular tissues œdematous Pain may be almost negligible, or may be exquisite, especially on movement. Tenderness is usually relatively slight. The constitutional disturbance in primary cases is often insignificant, though occasionally it is severe; in the secondary cases it is frequently conspicuous owing to the primary disease Several types may be distinguished:

1. The septicæmic variety is fortunately uncommon. The articular lesions are merely an incident in the course of a profound pneumonic toxæmia which overwhelms the patient at an early stage. The toxic mental symptoms may so dominate the picture that the patient himself fails to draw attention to the arthritis. Such cases are nearly always fatal.

2. The arthritis secondary to pulmonary pneumonia may occur before the respiratory signs are established, but most often develops just at the end of the ordinary course of the disease, about the ninth or tenth day. The ... may occur but the temperature rise again, or it may ... joint, usually the knee, shoulder, elbow, or ... hot and tender, and resistant to movement. ... especially when the joint is moved. Frequently, however, the signs and symptoms are of a subacute character.

3. The ordinary "primary" case in children is often characterized by some redness and by rapid effusion into a large joint, by a temperature between 99° and 102° F., by some malaise, and by pain, the intensity of which varies within wide limits in different cases. In many cases the constitutional disturbance is much less marked than would be expected from the pyarthrosis; even the local signs may be comparatively mild. In others the local signs are marke... slight. In more acute cases ... severe, but rarely so great a... staphylococci.

4. Primary pneumococcal arthritis in adults is rare, but may be very acute. The disease may begin with a rigor, the temperature may rise to 103° F., and articular pain may be exquisite, especially on movement; but even here the general intoxication is often less conspicuous than in suppurative arthritis due to other organisms.

5. Occasionally the disease runs a course so chronic as to resemble tuberculosis.

Prognosis.—The septicæmic cases are generally fatal; the patient is overwhelmed in a few days. When the arthritis is secondary to pneumonia the prognosis is better, but still bad. The arthritis is frequently evidence of a severe pneumonia, and, often arising when the patient is exhausted by his struggle against the pulmonary disease, turns the scale [illegible] cases generally recover under treatment. With [illegible] be regained, but in severe

Treatment.—General treatment for the pneumonia must be supplemented by evacuation of the joint. Frequently aspiration through a needle of wide calibre is all that is necessary. If this fails, arthrotomy and lavage should be performed with the most rigid precautions against double infection, and the joint then closed. Gentle passive and active movements should be commenced as soon as they cause neither exhaustion nor increase of effusion or other sign of inflammatory recurrence.

ARTHRITIS IN ENTERIC FEVER

During or after enteric fever one or more joints may, very rarely, become affected In the mildest form there is a sterile, rather persistent effusion which eventually is absorbed without leaving any disability. Very occasionally, however, the process is more acute: the involved joint becomes inflamed and filled with an exudate which rarely is converted into true pus; spontaneous dislocation may follow, the effusion should be removed by aspiration and the joint washed out; the result is usually good. But very rarely pyogenetic micro-organisms gain access to a joint during enteric fever, either alone or in symbiosis with B. typhosus; in such cases the prognosis as regards articular function, and even life, is bad, and treatment suitable for acute suppurative arthritis must be urgent and drastic.

GONORRHŒAL RHEUMATISM

The gonococcus, though in most cases confined to the urethra, vagina, and their immediate neighbours, may enter the blood-stream and be carried to distant tissues and viscera, there to cause gonorrhœal rheumatism in its various forms, or iritis, scleritis, or gonorrhœal septicæmia, pericarditis, endocarditis, myocarditis, pleurisy, meningo-myelitis, etc. Although always a difficult organism to detect in the blood and to cultivate, sufficiently numerous bacteriological proofs are now available to show that these general manifestations are due to blood-borne gonococci, either in pure culture or sometimes, in the most serious cases, mixed with other organisms derived from the urethra (*see* Vol. I., p. 816). In this article we are chiefly concerned with gonorrhœal rheumatism, which must be taken to include not only the articular and periarticular lesions but also those in tendons, muscles, fasciæ, and nerves; in these as in the commoner gonococcal periarticular manifestations the disease is primarily a fibrositis attacking periarticular tissues, nerve-sheaths, and fascial bands

Etiology.—The necessary etiological factor is the presence of a gonorrhœal discharge. Nearly always the seat of the original disease

is the urethra, but gonorrhœal rheumatism may be associated with purulent gonorrhœal ophthalmia, or more rarely with rectal gonorrhœa. It should be mentioned that a similar arthritis may very occasionally arise in connexion with a vulvo-vaginitis which is apparently *not gonorrhœal, or with faulty* instrumentation of the urethra. The rheumatism most commonly appears at or after the third week of the urethral discharge, often during its decline; but it may commence after a longer period, even some months after the beginning of the urethritis, when only a slight gleet remains. There seems to be no definite relation between the virulence of the urethritis and the likelihood of gonorrhœal rheumatism. The frequency of the articular complication of gonorrhœa has been stated to be 1 case in 45.[1] The age-incidence is indeterminate; whilst most cases occur in youth, during the period of greatest exposure to risk of gonorrhœal infection, the condition is well recognized in infants as a sequel of ophthalmia neonatorum or of vulvo-vaginitis, and also in old patients. Males are affected in a degree greater than is explained by the ratio of gonorrhœal infection in the two sexes; among the explanations given of this disproportion may be mentioned the concealment by women of vaginal discharges, the confusion in the patient's mind between gonorrhœa and a simple leucorrhœa, the comparative lack of absorption from the vagina, the much shorter urethra in the female, and the absence of the prostate, *in the crypts of which the gonococcus* is apt to find an agreeable nidus. The influence of exposure to cold is slight but, I think, definite, and that of injury is questionable; but there can be no doubt that a joint which has once been the seat of gonorrhœal arthritis is in a marked degree liable to further attacks if gonorrhœa be again contracted. Moreover, in seamen it was my experience that gonorrhœal arthritis was relatively more common in the wrists of stokers, and the ankles of deck-hands accustomed to work barefoot, than would be expected from general statistics.

1. Non-Articular Gonorrhœal Rheumatism

Although this variety is clinically very important, it must in this article be dismissed curtly, the reader being referred to the article on Gonorrhœa (Vol. I., p. 882).

Bursæ, tendons, muscles, fasciæ, and nerve-sheaths may all be inflamed, either alone or in association with arthritis of a neighbouring joint. Sciatica is not uncommon, and brachial neuralgia may occur. Paraplegia due to meningo-myelitis has also been recorded (Gowers). Pain in the heel on pressure is a common phenomenon, and may be due either to inflammation of the plantar fascia or to periostitis of the os calcis (Garrod). One of the commonest causes

[1] Loloir, Besnier, quoted by Mauclaire.

of flat-foot originating in *adult* life is stretching of the plantar fascia secondary to gonorrhœal inflammation.

2. Articular and Periarticular Gonorrhœal Rheumatism

Pathology. The joints affected.—The knee is by far the commonest victim—it suffers, alone or with other joints, in about two-thirds of all cases; while the ankle is attacked in about one-quarter, and the digits in about one-sixth of cases. The hip, wrist, shoulder, and elbow follow in that order of frequency. Other joints that are less often affected are the tarsal, temporo-maxillary, sterno-clavicular, vertebral, and sacro-iliac articulations. The number of joints involved varies in the different clinical types, but the disease tends to present an oligo-articular distribution, rarely attacking more than three or four joints. Frequently two or three are asymmetrically affected, but one large articulation bears the brunt, the disease rapidly subsiding in the others.

The **morbid anatomy** varies with the clinical type and is not very characteristic. The synovial membrane and subsynovial layers show some polynuclear cells which may contain a few gonococci, demonstrable with difficulty. Gonococci are occasionally found in the intra-articular effusion, but seem to die there at an early stage, so that the fluid is usually sterile.

The periarticular tissues may be œdematous; comparatively slight intra-articular adhesions and periarticular fibrous contractures may be present, but in the rare plastic form the adhesions are very strong and destroy articular mobility.

Intra-articular effusion is relatively slight in many cases, but in one of the commoner types is the predominant feature.

Muscular atrophy is present, as in most continued articular diseases, but it is not often conspicuous.

Clinical features.—The severity of the disease varies within wide limits, from a mere arthralgia to the severe, though fortunately uncommon, suppurative variety or plastic ankylosing form.

i. Slight wandering *pains* in one or several joints without any swelling or redness are common in gonorrhœa; they are not severe and are only present on movement.

ii. Sometimes the pain is severe and persistent enough to deserve the title *arthralgia*, but still is unaccompanied by obvious physical signs

iii When the arthritis is of a comparatively asthenic type it often manifests itself as a *hydrarthrosis*; there is subacute synovitis with considerable intra-articular but little or no periarticular effusion, often monarticular in distribution and chronic in course. The onset is frequently insidious, but may be rapid; the hydrarthrosis

is usually free from severe pain and from general or local reaction; occasionally, however, slight inflammatory symptoms are present. The effusion is serous, is persistent, and shows a tendency to recurrences.

After a prolonged course this type tends to recover without leaving any after-effects, except a liability to recurrence if fresh infection occur. Clinically it somewhat resembles a rheumatic hydrarthrosis, but, unlike it, shows no tendency to flit from joint to joint.

Very rarely suppuration occurs and a pyarthrosis develops.

Although very frequently monarticular, the hydrarthrosis may, especially at first, involve more than one joint.

iv. In other cases of low-grade infection a *subacute or chronic oligarthritis* develops, in which the *periarticular* tissues are the chief sufferers. This, the commonest form of gonorrhœal arthritis, affects two or three joints, rarely more; at the onset, however, many joints may be involved, but most of them very rapidly clear up Large joints, especially the knee, are the chief sufferers, but the digital and other small articulations may be secondarily involved.

Intra-articular effusion is scanty, but periarticular swelling, with perhaps some local heat and pain on movement, is marked. The onset is often insidious and the progress slow, but resolution is usually eventually complete. Not infrequently, however, fibrous adhesions, which can be broken down, are left, especially in the carpus, tarsus, and digits.

Muscular atrophy, always more or less present, is in exceptional cases conspicuous, rapid, and intractable.

All the above forms are of comparatively mild type and tend to complete recovery. But the following varieties are much more severe and may lead to considerable disability:

v. *Acute arthritis.*—In some cases after some comparatively insignificant pain, an acute arthritis may develop, usually in one but occasionally in two or three large joints. The pain becomes very severe and persistent, worse at night, and greatly exaggerated by movement or by pressure. There are local redness and heat, general fever, and considerable constitutional disturbance and sleeplessness. Periarticular œdema and swelling over and around the joint are marked. The intra-articular effusion is frequently turbid, and, although generally comparatively slight in amount, is occasionally profuse; the ligaments become infiltrated and softened and may allow partial dislocation The muscles are held stiffly and waste rapidly, the bone-ends may feel large, articular crepitus may be palpable, and the limb is functionally useless

vi. *Pyarthrosis* is, fortunately, a rare form of gonorrhœal arthritis, more likely to occur during the acute than the later stages of the

urethral discharge, though it may occur later. Definite suppuration may be present from the onset, or may occur in a joint already the subject of one of the more acute forms of gonorrhœal arthritis, such as that last described. The pyogenetic organism is most often the gonococcus itself, but there may be a mixed infection with gonococci and staphylococci ; although sometimes the pus withdrawn by aspiration appears to be sterile.

The onset of symptoms may be acute, subacute, or even chronic ; in some cases the differentiation from serous or merely turbid effusion is only to be made by finding pus with the exploring needle.

Even in the more acute cases the disturbance of general health and the local signs are less marked than in acute infective arthritis due to the streptococcus or staphylococcus, and the prognosis is better, deaths have occurred, but life is usually preserved, although the joint may be considerably disabled by ankylosis.

vii. *Plastic ankylosing arthritis.*—Ankylosis may follow pyarthrosis, but may also occur as the result of a quiet plastic arthritis. In this comparatively rare but prognostically important variety general constitutional disturbance is slight and local effusion moderate, but a fibrinous exudate forms in the joint and is converted into strong, broad adhesions. The ligaments show fibrotic contraction, and the articular cartilages and bone-ends are enlarged. The resulting ankylosis is strong, and often effectually interferes with articular mobility. The ankylosis may occur in vicious position ; in the knee, for example, flexion or even backward dislocation of the tibia on the femur may occur

Atrophy of neighbouring muscles is often marked and very persistent, even after treatment has abolished much of the rigidity. Restoration of mobility is seldom complete ; in advanced cases excision of the affected joint may be required. The disease may be so insidious that its connexion with a gonorrhœal discharge may be overlooked.

Diagnosis.—The more acute forms are liable to be confused with true rheumatism, or with an acute onset of rheumatoid arthritis, the more chronic with tuberculosis, or subacute rheumatism ; but the general characters (e g. the periarticular distribution in the common form of gonorrhœal arthritis), the presence of urethritis or gleet, or of ocular or even rectal gonorrhœa, the obstinacy of the arthritis, the comparative or complete absence of pyrexia, the rarity of cardiac complications, the absence of marked sweating and concentrated urine, and the X-ray appearances, will usually serve to differentiate it Moreover, if salicylate therapy is ineffectual, and if the temporo-maxillary joints be affected, true rheumatism is improbable. A monarticular or oligarticular distribution, especially in large joints

or the onset in several joints with *settlement in one or two*, is suggestive of gonorrhœal arthritis, even if the patient denies gonorrhœa.

The **prognosis** is, on the whole, good as regards the affected joint, and very good as regards life, even in the more severe forms. The arthralgic and hydrarthrotic forms gradually clear up under treatment. The subacute oligarthritic variety usually resolves, but may leave some ankylosis; the adhesions, however, are often readily broken down.

Of the more severe forms, the acute monarthritis frequently recovers completely, *but is very apt to lead to ankylosis.*

The pyarthrotic and plastic ankylosing types usually cause articular fixation, muscular atrophy, and considerable disability, especially if care has not been taken to control the position in which ankylosis occurs. The patient must be warned that recurrences are common, especially if gonorrhœa be again contracted or a gleet rekindled by alcoholic or venereal excesses. It must be remembered, too, that arthritis may be only one manifestation of a gonococcal septicæmia; also that some writers claim that rheumatoid arthritis may be one *of the sequels of gonorrhœa.*

Treatment.—The surgeon's primary therapeutic duty is to cure the etiological gonorrhœal focus by one of the methods described in Vol. I. (pp. 847, 862). Resolution of the arthritic condition is unlikely till the urethritis is cured, but then often follows rapidly.

The local treatment varies with the clinical type, but in all cases local and general rest, with the limb in a position that will permit the maximum usefulness if ankylosis occurs, is an essential, at any rate in the earlier and more acute stages.

Arthralgia may be relieved by soothing liniments or Bier's passive congestion, or in more chronic cases by counter-irritants such as iodine, Scott's dressing, or the button cautery. Hydrarthrosis calls for elastic pressure as applied by a Martin's rubber bandage, for pressure combined with counter-irritation as in the use of Scott's dressing, or, in severe and persistent cases, for aspiration of the joint with or without lavage with saline solution or a mild antiseptic lotion. Some *surgeons prefer arthrotomy to puncture* Evacuation, if employed, should be done early, before the formation of dense fibrinous masses.

Although Bier's method, employed for two or three hours a day, may in some cases relieve pain and promote absorption of the effusion, I have found it an uncertain remedy in this disease.

Subacute oligarthritis requires Scott's dressing and rest. Later, massage is of value, *and adhesions must be gradually broken down.* Bier's congestion is sometimes of use. Acute monarthritis demands *similar treatment*, but belladonna plasters and fomentations may

also be necessary to control pain. In the later stages, when there is no local heat, massage and passive movements should be adopted to exercise not only the joint but the periarticular tissues and neighbouring muscles. Hot-air baths and ionization with potassium iodide may then be of value.

Pyarthrosis should be treated by arthrotomy, evacuation, and lavage, followed by immediate closure; and rigorous care must be taken to avoid mixed infection.

In plastic ankylosing arthritis the position of fixation must be controlled at the same time that, by mercurial inunction, massage, and passive movements, efforts are made to prevent the ankylosis.

When ankylosis has occurred it may be overcome by manipulation under anæsthesia or by such operative measures as excisions or osteotomies.

In all cases quinine may be administered, or potassium iodide given to promote absorption of exudates and prevent fibrosis.

Gonococcal vaccines, especially if autogenous, sometimes prove useful, they are more successful in gonorrhœal rheumatism than in the treatment of the urethritis. In some cases a mixed autogenous vaccine composed of the organisms found in the patient's urethra is the most useful.

ARTHRITIS IN DYSENTERY

Arthritis is not seen in amœbic dysentery, but it supervenes in a small but definite proportion of cases of the bacillary form of the disease, especially when Shiga's bacillus is the infecting agent. This arthritis is distinct from the synovial effusions sometimes caused by serological treatment, and indeed there is evidence that to some extent its incidence is reduced by the early

symptom is articular pain, which may be severe, this is followed in a few hours by a rapid swelling of the affected joint or joints, often to a large size; more than one joint may be involved at once, or the effusions may occur in different joints at intervals When the patient has apparently entered on his convalescence his temperature may rise again, and it is observed that a joint, usually a large one, has become painful on movement, is stiff, and generally is filled with fluid The degree of effusion varies in different examples: in some it is extreme, in others mild, and in a few almost non-existent. The knee is most often attacked; after that the elbow and the

there is contamination with pyogenetic organisms.

During the late war a syndrome of dysenteric arthritis and ocular inflammation was observed; the eye signs took the form either of a painful non suppurative conjunctivitis with lachrymation, or of an irido-cyclitis. Muscular wasting is sometimes well seen

The **prognosis** is good, the effusion in nearly all cases subsiding without leaving any disability, except sometimes a little stiffness.

Treatment.—*Quinine may be given in 5-grain doses*, but is of doubtful benefit. Aspirin sometimes relieves the pain but does not remove the effusion. Sodium salicylate is valueless. Although the serological treatment seems to reduce the incidence of the arthritis, serum does not improve the condition once it is produced. Joints should be placed at rest and elastic pressure applied; Scott's dressing is often of value, but, if the effusion is extreme, aspiration is advisable.

ARTHRITIS IN ZYMOTIC DISEASE

Arthritis may arise during the course of or towards the end of almost any of the zymotic diseases, such as scarlet fever, measles, smallpox, diphtheria, mumps; in typhoid fever it is of relatively frequent occurrence (p. 889). The arthritis is due not necessarily to the specific micro-organism of the disease, but often to foreign microbes that have gained entrance to the blood through such a portal as an inflamed throat. Thus in a case of measles I have observed a pneumococcal arthritis. In many cases the intra-articular effusion is clear or only turbid, but in others it becomes definitely purulent.

ARTHRITIS IN URETHRAL CONDITIONS

Gonorrhœal arthritis has already been discussed, and it has been pointed out that similar articular disease may follow non-gonococcal leucorrhœa. Occasionally, but now very [illegible] observed to follow instrumentation of a [illegible] [pr]obably these cases are infective, althoug[h] [illegible] [ins]trumentation has caused no obvious urethritis. As a rule the effusion is clear, and the condition clears up after a few days' rest and elastic pressure.

TUBERCULOSIS OF BONES AND JOINTS

I. GENERAL

It is convenient to consider tuberculosis of bones and joints together, for in very many cases of articular tuberculous disease the primary focus is in connexion with the bones that enter into the articulation. It is possibly true that occasionally the disease may arise *de novo* in the synovial membrane or the perisynovial tissue, or may reach the joint by extension from a diseased neighbouring and communicating bursa; but in the great majority of cases the primary focus is osseous, either epiphysial, periosteal, or metaphysial. Nichols and others, as the result of examination of specimens removed by operation or at autopsy, have declared that practically all cases show evidence of osteal origin, and regarded the synovial and articular manifestations as secondary. Moreover, radiography not infrequently shows the presence of osseous lesions in the metaphysial region or in the epiphysis in early cases before any clinical signs of articular involvement are manifest; clinically, too, cases are sometimes seen in which the onset of symptoms, attributable to involvement of the joint

itself, is rapid, yet examination shows the presence of a bone lesion that must have existed before any articular signs or symptoms appeared. It is known that in acute osteo-myelitis the favourite site for settlement of the blood-borne organism is at the metaphysis or juxta-epiphysial line; thence the direction of spread in such cases is down the medullary canal and out under the periosteum, because the progress of the disease is too rapid to allow time for the bone to wall in the infective process; if the infecting organism is the B. tuberculosis, however, the process is much more chronic, and it is justifiable to assume that the reaction of the cancellous tissues, slight though it be to tuberculosis, is sufficient to wall off the focus from the remaining cancellous bone and the medullary canal; spread then naturally tends along under the epiphysial cartilage and to the epiphysis, and thence to the joint. Clinically, too, most surgeons are familiar with cases of tuberculosis in the epiphysis, associated sometimes, but not always, with disease in the joint.

The adjective "arthrosteal" is here used to denote cases of joint tuberculosis where the adjacent bone is clearly affected.

Etiology. Predisposing causes. *Age.*—No age is exempt, but the disease begins before adolescence in the majority of cases and is especially common before the age of 5 years Tuberculosis affecting the spine has been met with at the age of 3 months. As age advances, the severity of the disease is greater and the outlook less hopeful. In old age the incidence of osteal and arthrosteal tuberculosis again rises (senile struma), and then the lesion may run a destructive but, relatively to that seen in youth, a less painful course

Sex—There is no striking difference in susceptibility. On the whole, males are more often affected than females.

Heredity—While it cannot be positively denied that infection of the fœtus may occur, this must be exceedingly rare; the influence of heredity is probably that of bestowing tissues less resistant than normal.

Environment.—Fresh air, good food, and sunlight are important in maintaining the tissues at par. Bad hygienic surroundings are therefore a factor of prime importance. In older patients, chronic alcoholism and insanity are probably very indirect predisposing causes. The influence of syphilis, congenital or acquired, is not marked in the causation of arthrosteal tuberculosis

Trauma—Antecedent injury is a very frequent precursor of arthrosteal tubercle, particularly in the young. As a rule the injury is comparatively trifling—a slight blow or a moderate strain. Severe injuries are not usually followed by tuberculosis, probably because the reparative process is so active that the bacilli do not succeed in obtaining lodgment; also because the patient takes the severe injury seriously and rests. On the other hand, a sprain or a metaphysial twist, which probably leads to a slight extravasation of blood, is the type of injury that most commonly precedes osseous or articular tuberculosis

Local predisposition.—At all ages the order of frequency of involvement is—spine 23, knee 16·5, hip 14 6, tarsus 14·4 per cent.

Coexisting morbid conditions, such as septic teeth, enlarged tonsils,

adenoids, intestinal stasis, have all been blamed as favouring the onset of tuberculous disease.

Exciting cause.—The exciting cause in all cases is the Bacillus tuberculosis, either of the human or of the bovine type. Koch's statement in 1901 that the bovine variety is innocuous to man is undoubtedly incorrect, for

ratio with the care to exclude tuberculous milk from children's diet. In Scotland, Fraser, Mitchell and Stiles investigated 70 cases in children under 12 and found that 41 showed bovine tubercle bacilli, 26 human, and 3 both bovine and human. Stanley Griffith summarizes in tabular form the results ...ous tuberculous infections. His grand ... were infected with the human and 191 ...e mixed and 66 had atypical characters. As regards bone and joint tuberculosis his figures gave the following results:

Ages.	*Cases.*	*Human.*	*Bovine.*
0-5 years	84	57	25
5-10 „	167	121	42
10-16 „	90	77	8
16 and upwards	54	48	3
All ages	395	303	78

As compared with tuberculosis elsewhere, the bovine type was commoner in bone-joint tuberculosis (78 in 395) and in cervical-gland tuberculosis (50 in 108) than in infections in other parts of the body; in the sputum, for instance, in 229 cases the types found were—human 221, bovine 3, and atypical 5. Moreover, taking all lesions into consideration, the bovine type is commoner in the younger than in the older patients; thus:

Ages.	*Percentage of bovine.*	*No. of cases.*
0-5 years	37 55	221
5-10 „	29 45	312
10-16 „	14·66	150
16 and upwards	6 25	384
Totals	20 7	1,067

Pathology. Method of entrance of the bacillus. 1. *Ingestion.*—Probably the majority of cases become infected through the alimentary tract (*Calmette*). *Allusion has already been made to the part* played by milk.

Children crawling on dust-covered floors may also infect themselves, particularly if there be in the same house tuberculous individuals who expectorate promiscuously; the fingers become contaminated, and the *transfer of the organism to the mouth is easy.*

From the mouth, infection is probably conveyed to the tonsils, and thence to the cervical glands. If the bacilli are swallowed, infection of the mesenteric glands frequently occurs, the resisting powers of these glands in infancy and early childhood being distinctly less than at a later period of life.

2. *Inhalation.*—Where the society of tuberculous patients is intimate and unavoidable, this source of infection is probably frequent. The tonsils, the cervical and the bronchial glands, are probably halting-places on the way to the blood-stream.

3. *Inoculation.*—This is the least frequent mode of entry. Cases are described of local infection after circumcision or skin-grafting. The verruca necrogenica may become the starting-point of tuberculosis in the adult.

However introduced, the bacillus generally finds its way to the main lymph-stream in the thoracic duct, and thence enters the blood-stream. In the absence of a suitable nidus for development, the organism is probably destroyed, but if a patch of blood-clot or devitalized tissue is present it is apt to settle in this and to initiate a tuberculous lesion. Should this nidus be in the neighbourhood of bone or joint, osseous or articular tuberculosis is the sequel.

Infection atria to the joints and bones.—It is thus clear that tuberculous infection of bones and joints is practically always blood-borne.

Lexer (1904) demonstrated a rich vascular supply in the neighbourhood of the epiphysial line. At the site of reflection of synovial membrane on to bone a collar of small blood-vessels exists, the circulus vasculosus (first described by William Hunter). From this point vessels are given off to (1) the synovial membrane, (2) the epiphysis, (3) the metaphysis (sometimes).

In the case of the long bones the nutrient vessel, which enters about the middle of the shaft, sends branches towards the metaphysis, where they end in loops. Hence the blood supply is more free in the metaphysial region. Accordingly, a blood-borne infection is more likely to affect the metaphysis than any other part of the bone.

The site of synovial reflection in relation to the epiphysial cartilage varies in different joints, i e. in the hip-joint it is so placed that the epiphysis is entirely intra-articular. In the knee-joint, on the other hand, the synovial membrane is reflected on to the epiphysis itself; thus the epiphysis is partly intra- and partly extra-articular. This relationship is important in regard to the primary seat of osseous tuberculosis, i e. as to whether it is an epiphysitis or a metaphysitis Again, in the case of the short long bones, and the short bones, the nutrient artery of the bone breaks up almost immediately into a number of fine branches—i e. there is a similarity of vascular and cancellous arrangement in the short bones and in the metaphysial region of long bones; hence the comparative frequency of a tuberculous

osteo-myelitis involving the cancellous tissue in bones of this description.

The question whether bone or synovial membrane is first attacked has already been discussed (p. 896) It is possible that in some cases simultaneous infection of bone and synovial membrane occurs from the region of the circulus vasculosus.

Arthrosteal tuberculosis may thus be primarily located in one or more of five situations: (1) synovial membrane, (2) epiphysis, (3) metaphysis, (4) periosteum, (5) diaphysis; but I believe that a greater proportion arise, in connexion with bone than with synovial membrane.



Fig. 854.—Tuberculous disease of knee-joint.

The thickened, œdematous c... the synovial membrane from inflamma... is seen (*Dreadnought Hospi*... ...)

Morbid anatomy of tuberculosis of joints. —The essential pathology is the development of a tubercle follicle (*see* Vol. I. p. 760), composed of epithelioid cells with long nuclei and faintly staining and often branched cell bodies; in cases of sufficient duration one or more giant cells, with many nuclei arranged peripherally, may also be present; and near the margin of the tubercle lymphoid cells are usually to be seen Several tubercles fuse to form a nodule which soon tends to ne-cr... caseate in its ce... The nodules are st... titute of ca-

ficial layers become necrotic and ragged, and contain caseous nodules, and the deeper strata are converted into more or less developed fibrous tissue. From the edges a juicy pannus of tuberculous granulation tissue extends over the articular cartilage, pits and erodes it, probably partly by the digestive power possessed by most young cells; at the same time granulation tissue, derived from the diseased synovial membrane or from a primary focus in bone, is edging its way under the articular cartilage and cutting it off from much of its nutrient supply; the *articular cartilage*, thus attacked from both sides, necroses and becomes perforated.

The *bone* (*see* below) shows tuberculous osteitis of a carious type, either in the epiphysis or metaphysis, or in both. In a well established case, especially if double infection with pyogenetic organisms have occurred, small spiky osteophytes are formed round the margins of the articular surfaces.

The joint is generally filled with the thickened synovial tissue, and does not contain much fluid. But in one form of the disease, tuberculous *hydrops*, effusion is abundant. The effusion is thin and serous, contains lymphocytes, and in some cases rolled grain-shaped masses of fibrin known as *melon-seed bodies.*

Morbid anatomy of tuberculous periostitis.—The ribs, vertebræ, and sternum are the usual sites of primary periosteal tuberculosis. The process commences in the deeper layer of the periosteum, and thence may spread to the soft parts, or track along the Haversian canals into the interior of the bones, producing a tuberculous periosteo-myelitis. The bone becomes thinner and presents a worm-eaten appearance. "Spontaneous" fracture may occur In the case of the ribs the abscess may track a considerable distance before "pointing." The vertebræ of the adult when affected with tuberculosis most commonly present a periosteal infection. Several vertebræ may be involved and a large abscess formed before bony deformity occurs. Such an abscess, in connexion with the cervical vertebræ, may cause the formation of a retropharyngeal abscess behind the prevertebral fascia. From the upper dorsal vertebræ an abscess may track along the corresponding rib and point in front; from lower vertebræ it usually passes downwards to form a lumbar or a psoas abscess. In every case of apparent tuberculosis of ribs or sternum it is necessary to examine the spine. In children, on the other hand, vertebral tuberculosis more often causes a tuberculous osteo-myelitis with crumpling and angular curvature. The retropharyngeal abscess of childhood, moreover, is often not spinal or tuberculous in origin, but arises in the lymph-glands and tissues in front of the prevertebral fascia; it may, therefore, be opened from the mouth, whereas the tuberculous abscess must not be so evacuated, but should be reached from the neck.

Morbid anatomy of tuberculosis of bone.—However infected, the essential pathology of tuberculosis in bone, as elsewhere, is the development of a tubercle follicle (*see* Vol. I., p. 760). The prominent element in this is the "epithelioid" cell. Sometimes the tuberculous process manifests itself not by the development of separate nodules, but by "tuberculous infiltration." Here the epithelioid cells either run through the tissues in broad tracts or are scattered irregularly throughout the other tissue elements.

The fate of the tubercle bacilli may be one of three:

1. Death, leading to atrophy and disappearance of the tubercle follicle.

2. Latency, secured by (*a*) changes in the follicle itself of the nature of fibrosis or of calcification; (*b*) changes in the surrounding tissues tending to limit the infective area; these latter changes are *in the nature of fibrosis or osteo-sclerosis.*

3. Progress, leading to coalescence with other tubercles, caseation, and breaking down.

The caseous material which results from the breaking down of tuberculous tissue is not true "pus"; it consists rather of curdy necrotic material mixed with serum.

Certain changes are always associated in varying degree with the *development of bone tuberculosis. The morbid anatomy of tuberculosis* of bone is essentially that of tuberculosis elsewhere, viz. chronic inflammation. Of necessity, however, the nature of the battle-ground renders certain features more prominent.

In the *marrow*, there is an infiltration with "small lymphocytes" and "epithelioid" cells, occasionally and exceptionally preceded by a transitory polymorph infiltration lasting only a few days. As long *as the tuberculous process is active these two types of cells remain;*

In the *bone lamellæ* two processes occur synchronously—(*a*) rarefaction or absorption, (*b*) hyperostosis or thickening. The lime salts disappear from the connective-tissue ground substance, and the fibrous elements remain as representatives of the lamellæ. Hyperostosis is brought about by osteoblasts which deposit successive layers of bone upon the surface of the original lamellæ; it is characteristic of the most chronic forms of bone tuberculosis, but is never strongly developed; such a layer of more condensed bone may wall in a *tuberculous focus, e g. in the upper end of the tibia.*

The *periosteum* becomes more vascular. The first action is taken by the osteoclasts. They eat out a series of lacunæ along the surface of the bone; their activity then ceases, and the osteoblasts lay

down layers of bone which are firmly attached owing to the rough surface left by the previous action of the osteoclasts.

The *blood-vessels* may also show definite and characteristic changes (endarteritis obliterans), but never so markedly as in syphilis. The inner coat is thickened by the concentric deposit of laminæ of connective tissue. The internal elastic lamina and the tunica media show



Fig. 855.—Tuberculosis of knee, showing granulation tissue and erosion of cartilage and bone.

no change. Around the tunica adventitia there is a development of connective tissue These changes are probably the result of the circulation of a tuberculous toxin.

Spread from bone to joint, and joint to bone.—Occasionally the joint is entered by erosion of the cartilage from its deep surface. (Fig. 855.) Most frequently, however, the tuberculous process spreads from the metaphysis towards the neighbourhood of the circulus vasculosus.

Here the reflection of synovial membrane occurs, and at this spot the synovial tissue is invaded. *A thin sheet of tuberculous granulation* tissue grows inwards from the line of reflection; this is usually known as the "tuberculous pannus." Beneath it the cartilage undergoes retrograde change into fibrous tissue, and this fibrous tissue, as a rule, becomes invaded by the tuberculous process and ultimately undergoes caseation. Small pits filled with granulation tissue are formed over the surface of the cartilage. By gradual erosion and coalescence the cartilage becomes detached and the bone is laid bare. When surface pitting has advanced to a considerable extent the tuberculous granulation tissue may spread transversely between bone and cartilage, detaching cartilaginous flakes of considerable size. When the bone is exposed, disintegration is more rapid, *and is accompanied by "starting-pains" at night.*

The tuberculous joint may be almost completely filled by the vascular synovial membrane. When the contents are fluid there may be in the joint a large number of masses of fibrin, usually designated "melon-seed bodies." The presence of "pus" in a tuberculous joint is not very frequent

Gross pathological varieties of bone tuberculosis.—The following varieties may be distinguished, but it must be remembered that in a case of long standing several types may co-exist.

(1) "Encysted tuberculosis" of bone. Here the reactive processes are in the ascendant It is the most chronic variety, and may remain for long unsuspected.

(2) In the case of "infiltrating tubercle" the destructive processes are stronger, caseation occurs early, rarefaction proceeds, but, before it is complete, death of the lamellæ supervenes and rarefied sequestra are formed. If the bacterial products are sufficiently powerful or the tissue resistance sufficiently low, considerable areas of bone may die.

(3) The "intermediate type" usually begins as an "infiltrating tubercle," but the struggle is more prolonged Frail sequestra are formed, but finally the reactive processes gain the day and the focus becomes encysted. In this case the sequestra are usually small

(4) The "atrophic" type *has rarefaction of the bone lamellæ* as its predominating feature. It resembles "caries sicca."

(5) The "hypertrophic" type is distinctly rare. It attacks the ends of long bones and is associated with diffuse thickening of the bone. Transverse section shows it to be endosteal rather than periosteal.

(6) The "acute miliary" type *is found in connexion with* generalized acute miliary tuberculosis, and is unimportant surgically. It occurs as part of an acute generalized tuberculosis; frequently it is a terminal phenomenon.

Necrosis and sequestrum-formation.—There are three forms of sequestra—the minute, which are typically seen in the intermediate type of bone tuberculosis; the large rarefied, which occur in the course of an acute infiltrating lesion; and the dense sclerotic, frequently wedge-shaped. This last is the least common but the most interesting. It was formerly held that it was due to sclerosis occurring in an area of bone deprived of its blood supply by tuberculous embolism. This theory is nowadays not generally held. It has been seen that the lamellæ in the neighbourhood of a tuberculous focus undergo both rarefaction and some new-bone formation. Where this new formation occurs in excess—typically in the hypertrophic type, (5)—a portion of bone may undergo successive remodellings, hyperostosis and rarefaction occurring in turn The main tendency is to condensation, and ultimately a dense sclerosed sequestrum is formed. Death is brought about partly by interference with circulation, owing to some endarteritis obliterans of the vessels, and contraction of the newly formed fibrous tissue, or by gradual isolation of the sclerosed area by growth of granulation tissue.

Caries sicca merits separate mention. It is a rare disease, affects mainly the bones of the shoulder-joint, seldom suppurates, and is associated with marked atrophy of bone and obliteration of the joint cavity It occurs without apparent cause in young subjects otherwise healthy. Pain and limitation of movement are early symptoms. There is no swelling, gradual atrophy of the periarticular soft parts occurs, stiffness increases, and after one or two years the disease may cease, leaving firm ankylosis of the joint.

Pathologically the condition is due to the formation of dense tuberculous tissue, eroding cartilage, growing from synovial membrane, and gradually shrinking, forming firm fibrous tissue. This is accompanied by general atrophy of the bone of a concentric character.

Symptomatology.—Two distinct types must be considered —(1) the purely osteal, (2) the arthrosteal.

1. In the purely **osteal** infection there may be for some time a tuberculous nodule which develops, and finally becomes encapsuled without producing any symptoms of note. In other cases distinctive signs and symptoms are evident almost from the commencement; they are those of a chronic osteo-myelitis. No bone in the body can be said to be free from the possibility of infection, but the long bones most commonly affected are the tibia and ulna, especially in children. The phalanges, metacarpals, and metatarsals are also not infrequently the seat of tuberculous osteomyelitis (tuberculous dactylitis). In the long bones the disease usually commences in the neighbourhood of the metaphysis, and spreads along the medulla to a variable extent. In the case of the short

long bones—metacarpals, etc.—the infection is usually via the nutrient artery, and may commence either at the growing end or nearer the centre of the bone. At the same time the periosteum functions actively, so that in both cases the inflammatory process is accompanied by considerable apparent expansion of the bone; hence the name "spina ventosa" applied to the condition as it affects metacarpals or phalanges. In a *long bone, the diaphysial expansion* may be for some time the only sign present. The condition is usually met with in children; the swelling is of slow development, causes little pain, and may not seriously interfere with function.

The differentiation between tuberculous and syphilitic dactylitis is generally difficult, and sometimes impossible. A skiagram may show more diffuse thickening of bone in the syphilitic variety, but the Wassermann reaction is a more trustworthy indicator of spironemal infection. In either case a sequestrum may be formed.

As the disease progresses it involves in turn the cancellous tissue, the compact tissue, and the newly formed subperiosteal bone. In the end the periosteum breaks down and an abscess is formed in the soft parts. This may travel some distance along the line of least resistance before it comes to the surface. If it reaches the surface and spontaneously erupts through the skin, mixed infection is certain to occur, and a chronic sinus is thus established.

2. **Arthrosteal tuberculosis** betrays itself, as a rule, more readily. So long as the lesion is confined to the bone itself, no more indication may be given of its presence than in the condition described above, with which it is then indeed almost identical. Certain general symptoms may suggest a tuberculous lesion. The patient is often pale and "off colour." The appetite may be impaired; exertion readily induces fatigue, and may be followed by slight or marked rise of temperature. "A subnormal morning temperature of 97 5° or less, with an evening temperature of 99°, is practically pathognomonic of tubercle" (Robert Jones). Leucocytosis is generally absent.

Local symptoms of tuberculous infection are generally present from an early period. The earliest symptom is "*limitation of movement*," which must be in all directions. It is mainly due to muscular spasm of reflex origin. Under full anæsthesia it disappears, but presents itself again as consciousness is regained. While this spasm is useful in so far as it tends towards rest of the affected bone, it has the disadvantage of increasing interosseous pressure.

Osseous *atrophy* and *retarded growth* are early and constant symptoms. For the detection of this a skiagram which permits of comparison with the corresponding bone of the other side is most useful. The shadow of the affected bone is diminished, the individual tra-

beculæ may be seen to be rarefied, and there is loss of detail (*see* Vol. I, p 661). At a later stage actual diminution in size of the affected bone may be observed.

Swelling is another sign that is present from the first. It is detected easily in superficial joints such as knee and elbow or wrist, but with much more difficulty in deep-seated joints such as the hip; while it is impossible to make it out in spinal tuberculosis. The synovial membrane is felt to be swollen and pulpy. It is well to emphasize the importance of measuring with a tape measure at corresponding points, and noting at periodic intervals any variation in size.

Muscular wasting is pronounced at an early date, and involves all the muscles acting upon the joint, both proximal and distal. It is generally more than could be reasonably accounted for from simple disuse of the joint, and the explanation is discussed on p. 872. The diminution in the bulk of the neighbouring soft parts tends materially to exaggerate the apparent swelling of the joint.

Pain is a very variable symptom. It is seldom severe in the early stages of the disease. Later, when destruction of articular cartilage has occurred, it may be severe and may take the form of "night-starts." As the patient is dropping off to sleep, all his muscles become relaxed; some stimulus causes sudden, sharp contraction of the muscles acting upon the diseased articulation, and the jarring of the affected bone produces sudden and severe pain.

Loss of function of the limb follows as a necessary sequel to the foregoing symptoms In the upper limb this is generally manifested by avoiding the use of the joint involved. In the lower limb, e g the knee, lameness results. This loss of function is most marked under two conditions—(*a*) in the morning after a night's rest; (*b*) at the end of the day The diseased joint takes longer than the healthy one to "get up steam," and is also more easily tired.

The affected joint may feel *warmer* to the examining hand than does its fellow

Evidences of intra-articular *effusion* are slight or non-existent in most cases, but in the comparatively uncommon tuberculous hydrops are quite definite. When melon-seed bodies are present in a case of hydrops they can sometimes be felt moving under the examining fingers.

Later in the disease, and especially in those cases which have been inefficiently treated, *shortening* may occur. This is due partly to the actual destruction of tissue, and partly, in growing patients, to the reflex retardation of growth that is always liable to occur in connexion with bone tuberculosis.

Deformity is another distressing sequel. The possibility of deformity should be kept in mind from the first. In many tuberculous

joints ankylosis is the best fate one can expect, and care should be taken that the position in which ankylosis occurs shall be the best for subsequent function. Deformity is nearly always *the result of* inefficient treatment.

Extra-articular abscess, which in some cases may be the first fact noticed by the patient himself, and the occasion of his seeking advice, will be dealt with more fully as a complication of the disease (p. 909).

Lymphatic-gland involvement is not associated with arthrosteal tubercle, but if a sinus form and mixed infection take place the related glands may be enlarged.

While the development of these symptoms and signs is generally a gradual process extending over weeks or even months, the *onset of the disease may be acute and the progress rapid. In such* instances it may be difficult to distinguish from an acute suppurative arthritis.

Diagnosis.—In a typical case the diagnosis is usually fairly easy. The youth of the patient, slight trauma sustained usually some weeks or even months previously, the gradual onset and insidious progress, the absence of acute signs, the lack of leucocytosis, combined with general failure of bodily health, all suggest tuberculosis.

Sometimes tuberculosis is present elsewhere, e.g. in the lungs or cervical glands. The character of the bone or joint, as seen with X-rays, may give *distinct indication (see Vol. I, p. 661). Actual* sequestra may be detected, and their situation and size gauged. Sometimes valuable information is obtained by examination of fluid aspirated from a tuberculous joint Films may be stained, cultures prepared, or the fluid may be inoculated into animals, e.g. guinea-pigs. The last is the most trustworthy test. Tuberculin is of considerable value as a test. This is only to be considered positive if a distinct focal reaction occur in the affected joint The value of the von Pirquet cutaneous test is confused by the frequency with which *a positive result is obtained, especially after infancy;* in children a negative result has significance

A complement-deviation test is sometimes made; Fried and Moser examined over 600 cases of osteo-articular tuberculosis and found that roughly 50 per cent. gave a positive complement deviation, a figure corresponding to the results of McIntosh, Fildes and Radcliffe, and Rieux and Bass; it is said that, in the absence of clinical tuberculosis elsewhere, a positive reaction is of value, but a negative has no significance.

Differential diagnosis.—Tuberculous periosteo-myelitis has to be distinguished from other chronic infective conditions of bone. The history of *onset is useful.*

When swelling is a marked feature and the disease is somewhat

localized, myeloma may be simulated. Periosteal sarcoma has also been mistaken for the condition. Of practical importance is the deduction that, in all cases where the tumour growth is suspected, examination by cutting into the growth should precede any operation—e.g. amputation—for its removal.

The differentiation between tuberculous and syphilitic dactylitis has already been discussed (p. 906)

When a joint is involved the conditions requiring to be distinguished are more numerous, and include such affections as acute rheumatism, chronic rheumatism, rheumatoid arthritis, osteo-arthritis, gonorrhœal arthritis, neuropathic arthropathies, and syphilitic effusions, particularly in adolescents the subjects of inherited syphilis. There may be occasional confusion with gout. Hæmophilic joints ought to be readily distinguished. Acute infective arthritis due to one of the pus-forming organisms or occurring in connexion with typhoid or scarlet fever should always be borne in mind.

Intermittent hydrops may cause confusion if an accurate history is not obtainable. Lesions of traumatic origin, and those due to the presence of a loose body or an injured intra-articular structure, can generally be differentiated. Hysterical joints may prove a source of peril in diagnosis. Sensory abnormalities and coexisting hysterical manifestations should be sought for. The differentiation of the condition is not, as a rule, difficult if the possibility of its occurrence be borne in mind.

Complications. 1. **Abscess-formation.**—This is probably the commonest complication of osteal and arthrosteal tubercle. The "pus" consists of necrotic tissue with a variable admixture of blood serum The great characteristic of a tuberculous abscess is its tendency to wander. It may make its appearance first at a considerable distance from the tuberculous focus. This is notably seen in the case of abscesses which form in connexion with tuberculosis of the spine An abscess originating in the spine has been described as pointing in the vicinity of the tendo Achillis, and it is by no means infrequent to have such an abscess showing itself in Scarpa's triangle. Similarly, pus originating from a tuberculous shoulder-joint may become evident on the inner side of the upper arm beside the biceps.

The direction of spread is controlled by several factors. Gravity is always important. Further, the line of least resistance is nearly always followed. The guides which direct the abscess on its journey may be blood-vessels, tendon-sheaths, nerves, fascial planes, or bursæ in connexion with joints or tendons. Muscular action probably also aids in the propulsion of the "pus."

A second characteristic of a tuberculous abscess, e g. a psoas abscess,

is its manner of becoming obvious suddenly. To-day a large collection is present; yesterday, equally careful examination failed to detect any such swelling.

The tuberculous abscess is also conspicuous by the lack of acute signs. For long there may be no localized redness or heat, and pain is sometimes entirely absent. Sooner or later the abscess tends to "point." The skin over it at some one point becomes reddened and thinned. Unless pressure is relieved by aspiration the skin finally gives way, the pus escapes, and other organisms gain access. The orifice of such a sinus is generally characteristic. The edges are weak, thin, unhealthy-looking. I believe that a tuberculous abscess never establishes communication with the exterior until it is pyogenetically infected; that the phenomena of redness and thinning of the skin are evidence that the "pus" is no longer purely tuberculous. The practical deduction is that a tuberculous abscess should be dealt with before the surgeon's hand is forced by the evident signs of imminent spontaneous evacuation.

2. **Sinus-formation** is always a serious complication of bone tuberculosis. The sinus seldom leads directly to the bone or joint involved; as may be readily demonstrated by radiography after the injection of bismuth paste, the track of communication is usually long and tortuous. The seriousness of sinus-formation consists in the accession of "mixed infection." The advent of alien organisms increases the relative virulence of the tubercle bacilli, adds to the chronicity of the lesions, and clinically causes higher fever and more pronounced signs of intoxication.

The long-continued presence of a discharging and pyogenetically infected sinus is frequently associated with *waxy disease* due to the poisons of the associated pyogenetic organisms. This tends to affect liver, kidneys, spleen, and intestinal canal. Clinically it is associated with diarrhœa and albuminuria.

3. **Deformities and dislocations** are frequently seen. They may be produced by actual destruction of tissue by the disease; e.g. in the hip the upper segment of the acetabular rim may be gradually eroded and a dorsal dislocation occur. This condition is generally referred to as "wandering acetabulum." Again, the reflex muscular contraction that always occurs when a joint is involved, combined with the relaxation and destruction of ligaments, etc., due to the disease, may gradually bring about such a condition as the "triple displacement in the knee." Here the tibia is displaced upon the femur backwards and rotated outwards, and the knee is flexed. The biceps flexor cruris usually incurs the chief blame for this displacement.

4. **Ankylosis** is specially liable to take place after mixed infection. In purely tuberculous lesions it is said to be always fibrous; when

mixed infection occurs it is frequently bony. Ankylosis is a complication which is often a "consummation devoutly to be wished." It should always be anticipated, and the limb so adjusted that if ankylosis does occur the position of fixation will be the functional optimum.

5. **Acute generalized tuberculosis** is a complication which is speedily fatal. Short of general diffusion of the virus, secondary involvement of the *lungs* is a serious complication. Of the gravest import is infection of the *meninges;* this is a complication especially to be looked for in children, and more especially after operative interference.

Prognosis.—This depends on many factors. The age of the patient is of great importance. In the very young and in the very old the outlook is bad; but, broadly stated, adolescence offers a brighter prospect in tuberculous infection of bone than does adult life.

The general health affects the prognosis very markedly, and any measures directed to raising its standard prove most beneficial. The social position and the hygienic habits of the individual influence the course of the disease, inasmuch as greater care can be taken of the patient, special arrangements can be made for open-air and sunlight treatment, and nutritious food and apparatus for treatment may be supplied with less regard to expense

The digestive power is an important prognostic factor. Part of the treatment is systematic and plentiful feeding. It is often found that digestive capacity develops greatly as improved hygiene is adopted.

The presence of complications has a grave bearing upon the outlook Abscess-formation is serious, but sinus-formation is very serious. It lengthens the period required for conservative treatment, and renders such treatment less simple. It enormously increases the operative risk, and diminishes the value of the ultimate functional result in a similar degree. If operation be undertaken at a later date for rectifying the deformity or reconstituting an articulation the former presence of sinuses adds much to the odds against success. Once the region has been "septic," traces of the sepsis remain for years.

Of value also in gauging the prognosis is the reaction to treatment. The most trustworthy indices to improvement are absence of fever, gain in weight, improvement in general bodily condition, and return of function, in patients treated by heliotherapy, pigmentation of the skin implies more active reaction and a better prognosis But in all cases the treatment must be prolonged, and should continue for many months after symptoms have disappeared.

General treatment. 1. **Hygienic.**—In no form of tuberculous infection is it more important to have the patient under

favourable conditions than in tuberculosis of bone or joint. Climate is probably of less importance than in tuberculosis of the lungs; but fresh air, sunshine, and abundance of good food are essential. Where possible, cases should be treated out of doors. No place more unsuitable can be imagined than the crowded wards of a general hospital. Sunshine retards the growth of the tubercle bacillus, and probably the penetrating ultra-violet rays exercise a beneficial action on the disease. Excellent results have followed heliotherapy as practised at Leysin, Alton, and elsewhere.

Diet must be systematically excessive, and should not emphasize any one dietetic element. Fats, proteins, and carbohydrates should all be supplied in ample quantity. At the same time, care must be exercised not to upset the digestion by a too hurried exhibition of nourishment, and the food chosen should aim at providing the maximum of nourishment with the minimum of digestive difficulty. Thus milk, eggs, butter, cream, should form the bulk of the food. The consumption of fruit should be encouraged. Cod-liver oil has long been a stand-by in tuberculous conditions. Where patients find it difficult or impossible to persevere with pure oleum morrhuæ, one of the more palatable emulsions may be substituted. In the case of children especially the combination of cod-liver oil and malt is ingested with avidity.

In a few instances patients will be found to do better with pure olive oil The product must be absolutely pure; the ordinary "olive" oil of commerce is worse than useless for the purpose. Petroleum is sometimes employed with advantage; it is not itself absorbed from the alimentary canal, and probably produces its beneficial effects by aiding in the evacuation of the bowel. Raw-meat sandwiches are extensively used and form quite a palatable method of taking protein. Raw meat is more easily digested than cooked meat.

The second essential is *rest*. This must be absolute as regards the region affected, but need not be so as regards the body generally. Thus, general massage is a powerful aid in maintaining the health. The area of disease must be strictly avoided. Rest of the region affected will be considered in connexion with local treatment (p. 913).

As part of the general treatment of tuberculosis of bones, systematic examination should be made of ear, nose, and throat. The teeth should be thoroughly overhauled; tonsils and adenoids should be dealt with; any local focus of pyogenetic infection should be evacuated.

2. Of specific forms of treatment the most interesting is the use of tuberculin, but, although many variants of method have been adopted, it has, on the whole, proved disappointing. Certainly, in the case of children tuberculin is, as a rule, unnecessary.

Local treatment. 1. Conservative treatment consists in counter-irritation and rest. (*a*) *Counter-irritation* may be advantageously combined with local rest and with pressure by means of Scott's dressing (p. 885). Bier's congestion has been employed. It may be induced either by compression-bandage or by suction-cupping for two or three hours out of the twenty-four. It "undoubtedly lessens pain in the inflamed area." The degree of hyperæmia aimed at must never be such as to increase pain, and the circulation through the part should be retarded but not stopped.

(*b*) Local *rest* is of the greatest importance in the conservative treatment of this disease. It must be persisted in long after cessation of all acute manifestations, and the return to activity must be very gradual. Rest may be compassed in several ways. The principles involved are—

Fixation of the affected joint.

Protection of the joint from weight-bearing.

Traction to separate the diseased joint-surfaces.

Fixation of the affected joint may be brought about by different methods One of the most generally useful is by employing plaster. Celluloid splints have also been made use of on account of their smaller weight, but, in the early stages at least, plaster remains superior. When ambulant treatment is permissible, celluloid has distinct advantages. In applying the plaster it is necessary to have the joint in the correct position. Where the joint to begin with is in a bad position, correction must be accomplished either by gradual extension or by the application of a series of plasters one after the other. Forcible replacement of a displaced or malposed limb is quite unjustifiable. The limb having been got into the right position—i e. the normal position if complete resolution be anticipated, and the optimum functional position should ankylosis be expected—extension should be applied. This decreases interosseous pressure by separating the apposed joint surfaces. It keeps the patient from moving the joint and materially adds to his comfort. Starting-pains are diminished from the commencement and are usually speedily abolished. Traction may be applied by special splints, or—what is certainly best in the acute stages—by weight and pulley, while the patient is at rest in bed The weight must be so adjusted that it serves to keep bony surfaces apart without unduly stretching the ligaments of the joint. Traction should decrease discomfort; if the latter be increased it is usually an indication that the weight applied is excessive and the ligaments of the joint are being strained. It is of the utmost value to place the limb in a carriage or cradle so that one can control with some approach to accuracy the degree of traction applied. The prevalent practice of allowing the limb to

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rest on the mattress while being extended is highly unscientific, the friction between the limb and the mattress vitiating the good effects of the extension as well as increasing the discomfort due to pressure on the heels.

2. **Operative treatment.**—The operative measures used in the treatment of bone and joint tuberculosis are numerous, and the indications for each vary with the conditions found. The simplest of all is aspiration of the "pus." At the other extreme is amputation of the limb concerned. Intermediate measures are—the injection of various substances; aseptic incision and closure without drainage; arthrectomy (or "erasion" of the joint), a term applied to removal of all the diseased tissue concerned; excision of the joint, a more extensive removal of tissue, including all the synovial membrane, the articular surfaces, and a thin plate of bone.

Aspiration is adopted in order to forestall spontaneous evacuation of the abscess through the skin. Should spontaneous evacuation occur, pyogenetic mixed infection is inevitable and the gravity of the condition is much increased. Aspiration may be performed with an ordinary trocar and cannula to which is attached some suction apparatus. To avoid leaving in the skin a round hole, caused by an aspirating needle, liable to close comparatively slowly and therefore to supply a possible track for the spread of organisms from skin into joint, it is my custom to aspirate after making with a narrow-bladed knife a small linear skin incision which will close at once. The track may be made valvular by sliding the skin before incising. In many cases the "pus," consisting as it does mainly of necrotic tissue, is too thick to pass through the tube. Aspiration is then usually supplemented by the injection of material which tends to render the "pus" more fluid. There are many preparations used for this purpose. One such is—camphor 2 pts., thymol 1 pt., sulphuric ether 3 pts.; from 2 to 3 c.c. of this may be injected at a time. As a rule, two or three days later a thick viscous fluid may be withdrawn.

It is now less usual to combine with aspiration of the pus the injection of materials calculated to influence beneficially the course of the disease; this measure is of rather doubtful value, and sometimes

portion of sound skin should be selected, otherwise a chronic sinus is apt to develop at the site of puncture.

Following Murphy of Chicago, formalin (2 per cent) in glycerine has been used for injection into abscess cavities. It is well to prepare this on the day before use, otherwise droplets of strong formalin may remain unmixed.

Iodoform has long enjoyed a more or less deserved reputation in the treatment of tuberculous bone and joint lesions. It works best in a closed cavity, and is said to develop nascent iodine, a substance inimical to the tubercle bacillus.

Occasionally cases of iodoform poisoning occur in persons possessed of special idiosyncrasy. Undoubtedly the term "iodoform poisoning" includes many cases of septic infection. In cases of true iodoform poisoning the onset of symptoms is generally rapid, the gastro-intestinal canal is the seat of irritation, and there may be vomiting, abdominal cramps, and purging. Circulatory failure is speedily evident; the pulse becomes rapid and easily compressible, and fainting may occur. The cerebro-spinal nervous system is involved; delusions and hallucinations may be present. An erythematous rash may develop, although this is more frequently seen as an outcome of local application than of general absorption.

The principle underlying the use of these substances is that "cold" pus, consisting mainly of débris and lymphocytes, is lacking in proteolytic action, whereas "hot" pus is mainly composed of polymorph leucocytes, and has powerful proteolytic powers. By injecting irritants, such as iodoform or formalin, an attempt is made to attract polymorph leucocytes to the seat of the lesion, the hope being that along with the polymorphs proteolytic ferments will make their appearance.

Incision with drainage is a surgical procedure practically never to be employed in the case of unbroken abscess, for the risk of pyogenetic infection is extremely great.

Incision with cleansing of the focus, swabbing with iodine or flavine, is a suitable procedure in certain cases, provided the wound be sutured immediately and healing by first intention be obtained. In bone and joint lesions this method is of limited applicability.

Excision of the primary focus is a method of treatment sometimes advisable. It is of use only when the focus is in the bone and is of very limited extent. Asepsis must be maintained most stringently.

There remain for consideration the three major surgical proceedings of arthrectomy (erasion), excision of the joint, and amputation.

Of these three the one associated with least shock is *amputa-*

serious drawback. Robert Jones, who, following Thomas, is a strenuous advocate of conservative treatment, states that in his practice a set excision is unknown.

Stiles is the main protagonist for excision—even in children—"in cases in which the disease has progressed in spite of conservative treatment, and in those in which the disease is already far advanced when the children are brought for advice." He believes that the percentages of deaths and of amputations are much reduced by radical interference. He emphasizes the great and rapid improvement in general health shown by advanced cases after removal of the disease, as contrasted with what occurs under conservative measures.

One may sum up by saying that in all cases of early tuberculosis, whether in children or in adults, conservative treatment should be given an extended trial. Where the disease progresses in spite of conservative treatment the question of arthrectomy should be considered in children up to 15 or 16 years. In adults, where the lesion is progressive, excision should be performed. Amputation is comparatively rarely called for, and should always be preceded by less radical measures.

Treatment of complications. 1. Abscess-formation.—This has already been dealt with. Aspiration combined with injection, and aseptic incision without drainage, are the two methods usually employed. If the original focus becomes quiescent or heals, the abscess, as a rule, gives little trouble so long as it does not burst externally.

2. **Sinuses** around a bone or joint add to the difficulty of treatment in no small degree If they are numerous and extensive they may determine amputation to be the most promising treatment.

In the course of radiographic investigations of tuberculous sinuses, Beck found that bismuth injections possess a therapeutic as well as a diagnostic value. Various formulæ for the paste exist. One preparation is made by boiling 2 parts of vaseline and gradually adding 1 part of bismuth subnitrate. Other preparations that I use for the injection of sinuses are—(1) iodoform and vaseline, 1 drachm each, petroleum to 1 oz ; (2) bismuth subnitrate 6 parts, calomel 1 part, olive oil 2 parts, vaseline 12 parts. A glass syringe is sterilized in oil at 180° C., dried, and charged with the paste while the latter is still fluid ; the paste is injected until the patient begins to complain of the pressure; gauze is then packed into the opening of the sinus until the paste has solidified.

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tion, and in certain cases it is undoubtedly the operation of choice. Amputation is practised more in adults than in children. In the young the prospects of recovery under conservative measures are relatively so good that only extensive and rapidly progressing disease justifies the mutilation of an amputation. When tuberculosis elsewhere, especially phthisis, is present, and the patient's condition is rapidly deteriorating, the removal of a bone or joint focus is sometimes followed by great improvement in the lungs or other infected locus. In the case of weakly patients who are physically unfit for the shock attendant on a long operation, or in patients with waxy disease, amputation may be preferable to excision.

The chief indications for amputation are: (1) In adults, especially old people, much suppuration around the joint and septic sinuses riddling the neighbouring soft parts. (2) In adults, pronounced recurrence after a previous arthrectomy or excision. (3) In adults, the combination of progressive ill-health, of local advance in the disease in spite of conservative treatment, and of local bone changes so extensive as to make excision useless. (4) The commencement of amyloid disease. (5) The presence of disease elsewhere, which may be antagonized if the limb focus be removed. Each case must stand on its own merits; it is impossible to formulate cut-and-dried rules.

Arthrectomy, or erasion, is an operation which aims at removing the diseased tissue, the whole of the diseased tissue, and nothing but the diseased tissue. The last phrase distinguishes this operation from *excision*, where a layer of bone is removed deliberately so as to expose healthy bone underneath. Arthrectomy is a much more tedious operation than excision. The systematic dissection of the synovial membrane from such a joint as the knee is an operation calling for no little patience and assiduity. Free exposure is an absolute necessity. It is not so popular an operation as excision, because the risk of recurrence is greater. This means, of course, that all the diseased tissue has not been removed; the more careful and thorough the dissection the less is the proportion of recurrences.

As regards the subsequent utility of the limb, this varies with the situation of the joint and with the age of the patient. In the lower limb excision of the hip-joint is apt to leave an unstable joint, more so than arthrectomy. In the knee, on the other hand, excision —where bony ankylosis is deliberately aimed at—gives a more stable limb with, as a rule, less deformity than does arthrectomy.

In children up to the age of 15 or 16 excision is apt to interfere with growth at the epiphysial line. The shortening which occurs may be anything up to 5 or 6 in., and this is a very serious functional handicap. Stiles is of opinion that this disadvantage is overrated, but there is no question that when it does occur it is a

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The danger of bismuth poisoning must be borne in mind. The paste should not be injected into a sinus which has recently been

scraped. If the patient shows signs of gastro-intestinal irritation, blueness of the gums, and collapse, the paste should immediately be removed by syringeing with warm oil, followed by aspiration; *no scraping likely to open fresh paths of absorption should be done.*

Bismuth carbonate may be substituted for the subnitrate, but, though *less poisonous, it is also* more inert and less useful.

3. **Waxy disease**, in itself, calls for no special treatment. Its presence may *modify the treatment of the original lesion* in the direction of demanding earlier operative treatment (*see* p. 916).

4. **Deformities and dislocations** *should be anticipated in the* treatment, and extension applied to prevent their occurrence, or to rectify them when present. When associated with ankylosis, *adhesions should not be forcibly broken down.*

II. SPECIAL

Tuberculosis of the Hip-Joint
(Coxalgia, Tuberculous Coxitis, Morbus Coxæ)

Morbid anatomy.—The starting-point of the disease may be in either bone or synovial membrane. Statistics on the question are extremely diverse; the usual point of view is that its origin is in *bone rather more frequently than in synovial membrane. As regards* the actual site of the original focus in bone, this may be either the *acetabulum or, more frequently, the femur. If the disease begins* in the acetabulum, it is commonly in the vicinity of the Y-shaped cartilage. If the femur be primarily affected, it is generally at the metaphysis, the area of involvement being wedge-shaped and situated on the under-surface of the neck. This is the area in which synovial membrane is reflected from capsule to bone, and it is here that the "cervical ligaments" are well marked. Experimental injection of the aorta with lamp-black, the femoral artery being tied at the centre of the thigh, produces a mass of pigment in this area. The infection is probably from the circulus vasculosus, *along the retinacula into* that portion of bone where vascular anastomosis is most free.

A *corresponding explanation holds for* acetabular infection, since the vessels running in the ligamentum teres communicate with those *entering the bone* in the region of the Y-shaped cartilage.

Other parts of the femur may be primarily affected, e g. the head itself, or less frequently the great trochanter or the neck near it. In the latter two positions the condition may become encysted to form a circumscribed abscess in the bone, with indefinite symptoms but definite radiographic picture.

Probably the commonest course is establishment of the tuberculous

process at the lower part of the femoral metaphysis, spread thence to synovial membrane, to femoral head, and to acetabulum.

The subsequent progress of the disease is exactly that described earlier (p. 906). Sequestrum-formation is common.

Secondary results are mainly those due to pressure, and consist chiefly in absorption of femur or acetabulum, or both. The cartilages become destroyed and the softened and rarefied bones press against one another. This is most marked if the weight of the body is being borne upon the limb, but it may occur while the patient is recumbent, from reflex muscular spasm. The part of the acetabulum thus absorbed is generally the upper and back portion. As absorption occurs new periosteal bone is, as a rule, laid down in advance of the absorption, so that true dislocation rarely takes place, the condition being that of "wandering acetabulum." A similar process in the head of the femur leads to flattening and gradual disappearance of that part of the bone.

True dislocation, when it occurs in hip disease, usually takes place suddenly. The head and neck of the bone are shortened, the acetabulum is enlarged, and a quick movement may dislodge the head. When dislocation does occur there is generally marked synovial affection with much softening of the capsule, especially in its posterior and inferior parts, where it is normally thinnest. The usual direction is upwards and backwards, though forward dislocation is not unknown. Partial dislocation is relatively less rare. In this case the centre of the head catches on the edge of the acetabulum and becomes grooved by the pressure.

Coincident with these processes is the accumulation of tuberculous débris within the joint. At a later period chronic "cold abscesses" form in the extra-articular tissues. These may be intra- or extrapelvic. The most usual sites for these abscesses are (1) antero-external to the joint, (2) in the gluteal region, (3) inside the pelvis when the acetabulum has become perforated; the neighbouring bones may show either caries or osteophytic development. Should infection with pyogenetic organisms take place and the abscesses break down, chronic sinuses may be established around the joint, and necrosis and sequestrum-formation may ensue in the adjacent bone.

Clinical features.—Hip-joint disease is customarily considered in stages. The *first* stage corresponds to the period in which either synovial membrane alone is involved, or there is in the bone a localized focus that has not yet communicated with the joint. The articular cartilages are but little affected. The characteristic attitude is that of flexion, abduction, and eversion. There is never any shortening at this stage. The *second* stage corresponds pathologically to definite involvement of the articular surfaces; the

acetabulum is enlarging, the cartilages are being destroyed; there is always some shortening of the limb. In the advanced condition this is measurable; in the less advanced it may escape detection, the amount of shortening being within the limits of observational error. The typical attitude assumed by the limb at this stage is that of flexion, adduction, and inversion. Somewhat arbitrarily, this stage may be subdivided into two, namely (*a*) that of apparent shortening, and (*b*) that of real shortening. A *third* stage is sometimes described, the stage of recovery with deformity. Strictly speaking, this is a sequel rather than a stage in the progress of the disease.

It must be borne in mind that these stages pass gradually into one another; there is no sharp line of delimitation between them. They are chiefly of value as clinical subdivisions of the disease, although they correspond fairly closely to definite pathological events.

At any stage of the disease abscess-formation may occur. This is most frequently seen towards the end of the second stage. Abscess-formation will be considered more fully later (p. 925). Another complication that very occasionally may occur late in the disease is true dislocation, with giving way of the capsule.

Symptoms of the first stage.—The onset is usually gradual. There may be a history of injury, probably some weeks previously.

Pain is frequently absent in the early course of the disease, especially when the focus is limited to bone. The child complains of being easily tired, and usually walks with a slight limp This limp may be more pronounced in the morning, and wear off as the day goes on. The weight is thrown more on the toes; the knee and hip are thus kept partially flexed. The appetite becomes capricious, the face pale; the child may be peevish, and its sleep may be broken. These symptoms come and go, but finally they are more or less constant. Movement at the hip becomes more and more restricted, and the affected limb is dragged in walking. The characteristic attitude of the limb in this stage is that of flexion, abduction, and external rotation.

At the same time muscular wasting becomes apparent. This affects chiefly the glutei and the muscles of the thigh. Flattening of the buttock betrays gluteal atrophy. Loss of the gluteal fold is an indication of constant slight flexion at the hip-joint. The pain in the hip-joint tends to increase; pain may also be referred to the inner side of the knee; tenderness is frequently absent.

Deformity.—At this stage there is never any shortening, indeed there is often apparent lengthening. The attitude assumed by the limb is that of slight *flexion, abduction*, and *external rotation*; this is the position of greatest ease for the swollen joint because, as proved

experimentally in the cadaver, it is that of greatest cubical content. To accommodate this position of the hip to the erect posture and to enable the abducted limb to reach the ground in walking, the pelvis is tilted down on the affected side and then, to secure parallelism of the legs, the sound thigh is adducted; *apparent lengthening* of the diseased limb therefore results.

Secondary deformities follow in the endeavour to bring the axis of *gravity* between the feet; to compensate the *flexion*, *lordosis* is induced; whilst to overcome the declination of pelvis and spine towards the affected side, there is developed a *scoliosis* with convex

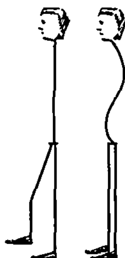


Fig. 856.—Flexion concealed by secondary lordosis.

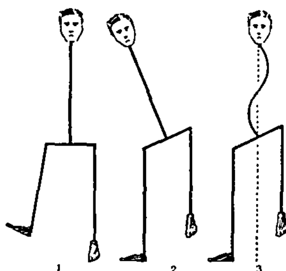


Fig. 857.—Early disease of right hip.

1 Abduction. 2. Tilting of pelvis to bring foot to ground, adduction of sound leg to secure parallelism of limbs Result Apparent lengthening 3 Scoliosis to bring axis of gravity back into intercrural plane

curve of lumbar spine towards the tuberculous side, and a compensatory *dorsal curve in the opposite direction* *These deformities*, primary and compensatory, may be represented in rough diagrams (Figs. 856, 857). When the patient is seen in this stage, therefore, the following deformities must be sought, viz. (*a*) flexion, partly masked by lordosis; (*b*) abduction with downward tilting of the pelvis and apparent lengthening, compensated by a scoliosis with lumbar convexity and dorsal concavity towards the affected side; and (*c*) external rotation which cannot be concealed.

The full actual degree of flexion may be demonstrated by laying the patient on a table and fully flexing the sound hip; the lumbar curve forwards is thus flattened out and the true flexion is manifested

internal rotation; and the apparent lengthening has given way to apparent and sometimes to real shortening if the destruction of acetabulum or of femur has proceeded to an appreciable degree. (Fig. 858.)

The explanation of the attitudes assumed is by no means a settled one. The early attitude of flexion, abduction, and external rotation is probably that in which the ligaments of the joints are most relaxed and the capacity of the articulation is greatest. During this stage the patient is frequently walking about, and the attitude assumed is that of greatest ease. In the more advanced disease the patient is, as a rule, confined to bed; the adductor muscles and internal rotators exercise greater power than their antagonists, and, as the patient tends to lie more on the sound side, the limb naturally falls over into the position of internal rotation. The posterior and outer part of the capsule of the joint is also said to be weaker and more yielding than the rest.

Apparent shortening of the limb follows naturally upon the adduction, just as in the first stage apparent lengthening followed abduction; the sequence now, however, is adduction, elevation of pelvis on diseased side, and apparent shortening; it results that the compensatory scoliosis has now changed sides, so that its lumbar convexity (and dorsal concavity) are towards the sound side. Apparent lengthening is measured by placing the patient flat on his back and the lower limbs parallel; the distance from external malleolus to umbilicus is then observed; the difference is equivalent to the apparent shortening. Real shortening is an estimate of actual loss of length of the limb. It is measured by observing the distance from the external malleolus to the anterior superior spine of the ilium, the limbs at the time occupying identical attitudes. It may also be noted by estimating the height of the summit of the great trochanter above Nélaton's line, by ascertaining that Bryant's triangle is smaller than on the sound side, or by finding that a lead bar laid from one trochanter to the other and another bar resting on the interspinous line converge towards the diseased hip instead of being parallel (Chiene's parallels).

In order to appreciate the position assumed by the pelvis, and hence the difference between the real and the apparent length of the two limbs, one fact only requires to be borne in mind, viz. that parallelism of the limbs is aimed at. As the affected limb makes its own standard, the sound limb must adapt itself to that standard. Hence, when the affected limb is abducted the pelvis is tilted so that the sound limb is adducted, and when the diseased limb is adducted the pelvis is tilted so that the sound limb is abducted. Flexion affects the antero-posterior tilt of the pelvis, and thus does not interfere with apparent lengthening or shortening. Abduction and

adduction influence the transverse tilt of the pelvis, while internal or external rotation does not appreciably affect the pelvis at all.

Lordosis, the device adopted to compensate for flexion, is easily demonstrated by making the patient lie flat on his back on a firm table. If the thigh on the diseased side be brought in contact with the table an obvious space appears between the lumbar spine and the table. This space is obliterated when the affected thigh is flexed on the abdomen, since movement occurs at the lumbo-sacral joint.

The amount of shortening that may occur is variable. It may be no more than ½ in., it may be as much as 2½ in., during the active stage of the disease. At a later period deficiency in growth may further increase the difference in length between the two limbs.

Another measurement sometimes taken, and one which is of use mainly in indicating whether true dislocation has occurred, or whether "wandering acetabulum" is present, is the relative distances of the great trochanters from the middle line. In true dislocation, which, though rare, may occur during the second stage, the head of the bone slips upwards on the dorsum ilii and the acetabulum becomes filled with granulation tissue. Here the trochanter is usually farther from the middle line. In the typical tuberculous hip without dislocation the great trochanter is usually nearer the middle line owing to absorptive processes occurring in the head and neck of the femur.

Examination of the rectum should never be omitted at this stage. Information may be obtained of an intrapelvic abscess, or, short of this, of fullness about the inner aspect of the acetabulum or tenderness in this region.

The subjective symptom of the second stage is mainly increased pain. Characteristic of destruction of articular surface is the presence of starting-pains. Pain is caused more readily by jarring movements. The signs of general intoxication, loss of appetite, fever, etc., are also increased. Muscular wasting may become very pronounced during this stage of the disease.

Abscess-formation in hip-joint disease.—While abscesses may occur at any period of tuberculous hip disease, they most commonly begin during the stage of flexion, adduction, and internal rotation. Their importance lies mainly in their liability to pyogenetic infection. So long as the "pus" of a tuberculous abscess consists only of tuberculous débris its bearing on the course of the disease is comparatively a minor one, but when pyogenetic organisms have gained access the outlook is enormously increased in gravity.

At a later period leakage occurs, and cold abscesses are formed in the periarticular tissues. This escape may take place through the acetabulum into the pelvis, or through the anterior aspect of the joint, but is most common through the weaker posterior part of

the capsule. The abscess enlarges and spreads in certain recognized directions. Most usually it appears in front between the anterior superior spine of the ilium and the great trochanter, either by direct extension beside the tensor fasciæ femoris from the front of the hip, or from the back, guided probably by the rotator muscles to the front, and then passing forwards. Less often it travels backwards through the buttock. Occasionally it follows the line of the pubo-femoral ligament to reach the front of the thigh internal to the femoral vessels; rarely at the same time it involves the subpsoas bursa.

Perforation through the acetabulum leads to the formation of a pelvic abscess, which then tracks either upwards to appear above Poupart's ligament or above the iliac crest, or downwards to form a pelvi-rectal and later an ischio-rectal abscess.

Then, if infection with pyogenetic organisms occur from the skin, the abscess breaks down, bursts, and leaves discharging sinuses in positions corresponding to the above directions of spread. The commonest point is beside the tensor fasciæ femoris, but sinuses are not uncommon in the buttock, internal to the femoral vessels, above Poupart's ligament or the iliac crest, or in the ischio-rectal fossa.

Pyogenetic infection is usually announced by increase of the evening temperature, together with local increase of pain and tenderness, redness of the skin, and heat. *Sooner or later such an infected* abscess tends to reach the surface, where it bursts, leaving a sinus. After this the usual history is pocketing of the pus, rise of temperature, burrowing of the pus in fresh directions, and new communications with the exterior, with coincident fall of temperature, until the soft parts may be riddled with sinuses.

This complication, if prolonged, may induce waxy disease; the patient's general condition deteriorates more or less steadily, and, if the condition be not *radically treated, progress downhill is steady* until death brings a welcome relief from suffering.

Symptoms of so-called third stage.—This is really the stage of recovery and is associated with ankylosis. By some it is contended that in purely tuberculous lesions the ankylosis is always fibrous, whereas if pyogenetic infection has taken place it is usually bony.

This stage is of importance chiefly on account of the deformities with which it may be associated. *Flexion—present throughout the* disease—may be excessive; adduction is a particularly troublesome deformity; shortening is generally present in a grave case, and is partly due to actual destruction of bone and partly, in children, to diminished growth.

A slight degree of flexion is not altogether undesirable, as it

enables the patient to sit down more comfortably; but much flexion is always combined with lordosis, and where there is adduction in addition to the flexion the practical shortening is much increased. These deformities should be foreseen and means taken during treatment to prevent their development.

Double hip disease is not very common. It is usually fairly advanced in one joint before the other is involved. If both hips pass into the condition of flexion, adduction, and internal rotation a most inconvenient crossed-leg deformity is the result.

Prognosis.—Tuberculous disease of the hip-joint is, of course, a very serious affection. If recognized early and placed under proper treatment, recovery may be almost perfect. Very generally, however, there is some limitation of movement. Pyogenetic infection is always a very serious factor in the outlook.

The time necessary for complete and thorough treatment is long; five years may be taken as an average.

The mortality usually mentioned in connexion with hip-joint disease is around 30 per cent. The causes of death are disseminated tuberculosis, e.g. tuberculous meningitis or pulmonary phthisis. Long-continued suppuration and the consequent waxy disease are responsible for many deaths. When the disease comes under observation in an advanced condition, with destruction of the articular surfaces, ankylosis is a desirable end. It is necessary to retain the use of fixation apparatus for a long time, as the tendency to flexion and adduction is so persistent.

Differential diagnosis.—In the early stages, especially where there is a history of injury, it may be difficult to distinguish tuberculous hip disease from a *simple traumatic arthritis*. In this case it is well to put the patient to bed for ten to fourteen days, and then note the effect of allowing him to get up and walk about. If the condition be simple, no ill effects are observed; if it be tuberculous, exercise increases the disability.

In the past many cases of *pseudo-coxalgia* have undoubtedly been treated as tuberculous disease of the hips Consideration of the age (between 5 and 10) at which pseudo-coxalgia begins is not of much service, for it is an age at which tuberculosis is often seen. But the mildness of the symptoms, the course of the lesion, and, especially, the radiographic findings (Plate 140, facing p. 945) will generally settle the diagnosis (*see* p. 944).

In children a "*slipped epiphysis*" (see p. 837) may confuse the diagnosis. A radiogram will generally settle the point. Slipped epiphysis is commonest between 12 and 17, and rarely causes marked flexion. In older people *monarticular rheumatism* or *rheumatoid arthritis* may provide a diagnostic problem. The age of the patient, the presence

of grating, tenderness, and leucocytosis on the one hand, or of other tuberculous lesions on the other hand, may aid in the solution.

Spinal disease, especially with abscess-formation, generally misleads owing to the presence of some degree of flexion at the hip. *If it be remembered that in a tuberculous joint movement is restricted in all directions*, this should not be a source of error.

Sacro-iliac disease should also be considered. In this condition the movements of the hip-joint are limited, but not in all directions.

Acute osteo-myelitis of the head of the femur or of the innominate bone may possibly be confused with hip-joint disease which is acute in onset. The high temperature and the raised leucocytosis should be a guide in differentiation.

In infants, *gummatous epiphysitis* with pseudo-paralysis is a possible source of error. This condition is comparatively rare in the upper end of the femur. The Wassermann reaction in these cases is positive, and other signs of congenital syphilis may be present. Gummatous epiphysitis generally affects infants of less than three months.

Acute pyogenetic infection of the glands in the groin ought not to cause difficulty, but this, as well as new growths of the pelvis or of the upper end of the femur, has been mistaken before now for acute tuberculous hip disease. The same may be said of *sciatica*.

"*Hysterical hip*" may for a time baffle diagnosis Special examination should be made for sensory disturbances, especially "stroking anæsthesia" When definite diagnosis is made, it may be well by the intraspinal injection of stovaine to convince the owner of the pseudo-arthritis that the joint movement is unimpaired.

Congenital dislocation of the hip and *coxa vara* may be mistaken for a more fully developed tuberculous lesion In both of these there may be limitation of movement, but not *in all directions*. If the affected thigh can be placed across the middle of the opposite thigh, tuberculosis of the hip-joint may be excluded.

In other patients *neuropathic joints* may betray the superficial observer. Movement here is generally excessive. An X-ray photograph generally makes the condition clear.

Infantile paralysis and *true dislocation, occurring either* as the result of trauma or in the course of an acute infective disease, should occasion *no real difficulty*.

Treatment.—In the early stages conservative treatment should invariably be adopted, and, if persisted in, *will nearly always* be successful in stopping progress of the disease. The functional

results are superior to those of operative treatment, the mortality is less, and there is less risk of dissemination of the disease.

There is little to be added to what has already been said in connexion with tuberculous joints in general; but one or two points deserve special mention.

The first aim is to secure rest, and to overcome pain and spasm; this is best done by putting the child to bed surrounded by sandbags *and by applying extension by weights that exercise their pull in the direction of the deformity.* The child may be laid flat on his back on a firm bed, and steps taken to obliterate the lordosis, so that the lumbar spines are in contact with the bed. Strapping is attached to the lower two-thirds of the thigh, and the weight applied through a cord led over a pulley which is placed at such a height that the cord is a continuation of the long axis of the thigh with the limb in the position adopted when the lordosis is obliterated. The next purpose is very gradually to rectify deformity by a steady series of changes in the direction of pull until the flexion and abduction or adduction are overcome, and the patient can lie straight without lordosis. In using weight-extension to correct deformity it is necessary to fix the pelvis; this may be done by applying weight-extension in the abducted position to the sound limb as well as the diseased one, and by getting counter-extension from the weight of the body by raising the foot of the bed. The eversion or inversion must at the same time be countered by the use of sandbags or of a foot-piece fixed to a short posterior splint or to a slot attached to the bed. When these ends have been attained, the patient may be fixed in the restful and corrected position by the application of a plaster-of-paris case for at least three months after the last sensation of pain; then he may be fixed in a Thomas hip-splint and allowed to get about on crutches and with a patten, 3 in high, attached to the boot on the sound leg.

Some surgeons, having overcome pain and spasm by weight-extension, immediately begin the use of plaster cases, frequently renewed, and each applied after a further correction of the deformity. For patients who can be easily looked after in bed I prefer not to use plaster cases until the correction has been made by weight-extension.

The bed should be narrow and should be firm. Either a special frame should be employed, or fracture boards should be placed beneath the mattress. A tripartite mattress is of great convenience for nursing. When the bed-pan is required the services of a second nurse should be utilized to support the pelvis during the removal of the portion of mattress and the insertion of the bed-pan.

To fix the limb, special splints, such as Jones's abduction frame, are frequently employed, which permit of a certain amount of abduction. The tendency to external rotation of the limb is very pronounced in

the first stage, and must be persistently counteracted. A long Liston splint is sometimes used, but is inefficient unless a great deal of trouble is taken in its frequent readjustments. It is a measure of considerable importance to apply a second long Liston splint to the sound side, otherwise the child will certainly wriggle about and attempt to sit up. A hinge in the Liston splint opposite the hip-joint permits of abduction to any desired degree.

Extension requires judicious use. Its design is to tire out the *muscles. Any weight used in excess of this stretches the ligaments* and tends to produce future instability; it also tends to increase pain. Strapping should be applied from the hip down to the knee, but should not extend below this level. It is desirable that no traction be exercised upon the knee-joint. The pull, to begin with, should always be in the direction which the long axis of the thigh has assumed. The return to "normal" should always be gradual. The importance of diminishing friction by the aid of some sort of carriage has already been mentioned (p. 913). The weight applied to begin with is variable, but probably 3 lb. or 4 lb. is sufficient.

Where possible, the child should be nursed in the open air. In small children this can often be secured by the use of a Phelps box, or *of a "pea-pod" plaster shell, made in such fashion that* either the anterior or posterior half of the pod or shell can be removed for nursing purposes while the child still reclines in the other half. In this way *the child can be carried about from one place to another without* disturbing the hip-joint in the least.

Later on, when the need for traction has largely disappeared, a double Thomas *hip-splint may be employed.*

When this stage is reached in the case of adults, a single Thomas splint (Fig. 859) permits of the patient walking without bearing weight on the joint. *Two points not generally recognized in connexion with* the Thomas splint may be referred to: (1) The bar which corresponds to the limb should be parallel (but on a plane slightly anterior) *to that portion which corresponds to the body. (2) The body portion* should be slightly rotated so as to fit the thorax, i.e. a right splint would have the anterior surface directed slightly to the left, a left splint slightly to the *right.*

A patten is fixed to the boot of the sound side, and the patient walks with crutches. Care must be taken, by the use of a rubber stirrup, to prevent *pointing of the toes of the affected limb. It must* be borne in mind that the deformity of flexion at the hip can persist or even increase while a Thomas splint is in use. Examination should be made *systematically with this point in view.*

When the absence of pain and thickening, the improvement in mobility, and the confirmation obtained by radiograms indicate that

the disease has been overcome, the weight of the body may be allowed to come gradually upon the joint. Thus, apparatus may be left off and the patient may go about on crutches. After this, he discards the crutches and walks with the aid of sticks. Finally, the sticks are set aside and he bears his full weight upon the joint.

While this régime is well adapted for patients under constant supervision, it does not always meet the needs of hospital practice. Here the use of plaster of paris is of much value in the fixation of the joint. It must be employed as a double spica, so as to include

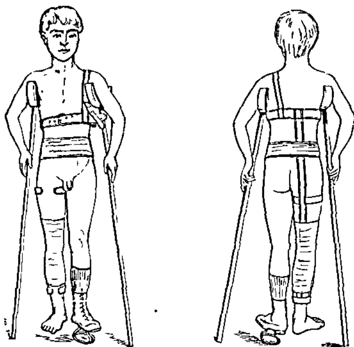


Fig. 859.—Thomas's hip-splint in use, front and back views.

the whole of the pelvis and the upper part of the thigh on the sound side, as well as the whole of the thigh and the leg on the affected side. An apparatus of this sort precludes locomotion and does not so readily permit of extension; it is therefore most useful when the necessity for extension has passed off. A similar retentive splint made of celluloid,[1] and permitting free movement of the affected hip, may be made when ambulant treatment is considered permissible. It is lighter than plaster of paris, can be made to fit more "snugly" than a Thomas splint, and is more efficient in preventing recurrence of flexion.

[1] For its preparation, *see* Gauvain, *Brit. Med. Journ.*, 1913, i. 1200.

When the disease is more advanced the principles of conservative treatment are the same, but they must be carried out for a longer period, and slight modifications of detail must be made to overcome deformities. Let us assume that there is some degree of actual shortening, flexion is considerable, and adduction and internal rotation are pronounced. The first thing is to fix the pelvis, and then, by adjusting the upright at the foot of the bed, traction can be applied almost in the line of the thigh but tending in the tiniest degree to give it a bias towards normal. At the end of a week or ten days the bias may be gradually increased. Infinite patience must be exercised, and forcible replacement of a malposition under anæsthesia is absolutely unjustifiable; it can only succeed in stirring up the smouldering embers of the disease. Because traction often only partially counteracts shortening due to actual destruction of bone, and because retarded growth is probable, it is well to provide functional compensation for loss of length by aiming at a final position of slight abduction.

Operative treatment.—This should not be undertaken unless the surgeon's hand is forced. *Arthrectomy*, which aims at complete removal of the whole of the diseased tissue, is, in the hip, almost impossible.

Excision of the joint, while more likely to be attended with local annihilation of the disease, is unsatisfactory as regards consequent function. Stiles removes the whole of the neck of the femur, and aims at implanting the summit of the great trochanter into the rawed acetabulum. Ankylosis is, of course, the desired goal. Kocher's posterior incision is employed. At the end of three weeks or so, when the wound is soundly healed, the limb is put up in plaster of paris. Stiles considers excision of the hip the best procedure in cases that have got worse in spite of a thorough trial of conservative treatment.

Disarticulation may be undertaken in the circumstances already detailed. A racquet incision which allows preliminary ligature of the main vessel is the best, but the presence of sinuses may modify the procedure.

The treatment of deformities arising as a result of tuberculosis of the hip-joint which has been cured is, strictly speaking, a matter for the orthopædic surgeon. Operations are undertaken to provide a movable instead of a fixed joint, e.g. Jones's operation or Murphy's arthroplasty. These should not be lightly entered upon Their whole success depends on the most complete absence of infection, and this, in an old tuberculous hip, is not always to be relied upon, especially if sinuses have existed. Moreover, the great desideratum in the lower limb is stability; mobility is a poor second. In bilateral hip

disease with "scissors" deformity a mobilizing operation should be attempted on one side only.

When ankylosis has occurred in bad position, this may be rectified by osteotomy. Adam's plan of dividing the neck of the bone, Gant's subtrochanteric or Maunder's intertrochanteric osteotomy may be tried.

Treatment of abscesses. 1. *Unbroken abscesses.*—Opinions differ as to whether the abscess should be treated alone, or whether the joint which is the *fons et origo* of the abscess should receive operative care. Stiles believes in dealing with the joint; others, where the abscess is extrapelvic, treat it alone without excising the joint. Aspiration and the injection of substances such as iodoform may be undertaken, but I am in the habit of relying chiefly on aspiration, without injection, associated with persistent fixation. The lining wall of the abscess should never be scraped. Though often stigmatized as the "pyogenic membrane," it is Nature's best effort at reaction. To remove it is to open up raw surfaces for the reception and probable dissemination of tuberculous infection.

2. *Opened abscesses*—Doubly infected abscesses occasionally heal after being freely opened and fully drained. Injection of the resultant sinuses with bismuth paste may give gratifying results. Vaccine treatment, especially if combined with Bier's suction, may assist in overcoming pyogenetic infection. Too often, however, these measures prove ineffectual, and the persistent pyogenetic infection leads to the development of waxy disease. In these circumstances excision of the joint is called for. Kocher's posterior angular incision gives best access to the joint. Whichever incision is employed, an attempt should be made to dissect out the sinuses. Disarticulation at the hip-joint or even interilio-abdominal disarticulation may possibly be required in special cases. The latter is an operation of very great severity, and is only, if ever, justified by a desperate outlook.

Tuberculosis of the Knee-Joint

Of all tuberculous arthrosteal lesions, those of the knee-joint (Fig. 860) are second in frequency, the spine being first with 23 per cent, the knee-joint having 16·5 per cent., and the hip-joint 14·8 per cent. The disease may occur at any age, but is most frequent before the age of 20 (68 per cent. of cases)

Pathology.—Apparently the synovial membrane and the bone are primarily affected with almost equal frequency. When bone is primarily affected the most usual situation is in the epiphysis of the femur or of the tibia. In the femur the metaphysis is more rarely involved The explanation is probably that the upper end of the synovial membrane and its reflexion on to the capsule lie in relation to the

When the disease is more advanced the principles of conservative treatment are the same, but they must be carried out for a longer period, and slight modifications of detail must be made to overcome deformities. Let us assume that there is some degree of actual shortening, flexion is considerable, and adduction and internal rotation are pronounced. The first thing is to fix the pelvis, and then, by adjusting the upright at the foot of the bed, traction can be applied almost in the line of the thigh but tending in the tiniest degree to give it a bias towards normal. At the end of a week or ten days the bias may be gradually increased. Infinite patience must be exercised, and forcible replacement of a malposition under anæsthesia is absolutely unjustifiable; it can only succeed in stirring up the smouldering embers of the disease. Because traction often only partially counteracts shortening due to actual destruction of bone, and because retarded growth is probable, it is well to provide functional compensation for loss of length by aiming at a final position of slight abduction.

Operative treatment.—This should not be undertaken unless the surgeon's hand is forced. *Arthrectomy*, which aims at complete removal of the whole of the diseased tissue, is, in the hip, almost impossible.

Excision of the joint, while more likely to be attended with local annihilation of the disease, is unsatisfactory as regards consequent function. Stiles removes the whole of the neck of the femur, and aims at implanting the summit of the great trochanter into the rawed acetabulum. Ankylosis is, of course, the desired goal. Kocher's posterior incision is employed. At the end of three weeks or so, when the wound is soundly healed, the limb is put up in plaster of paris. Stiles considers excision of the hip the best procedure in cases that have got worse in spite of a thorough trial of conservative treatment.

Disarticulation may be undertaken in the circumstances already detailed. A racquet incision which allows preliminary ligature of the main vessel is the best, but the presence of sinuses may modify the procedure.

The treatment of deformities arising as a result of tuberculosis of the hip-joint which has been cured is, strictly speaking, a matter for the orthopædic surgeon. Operations are undertaken to provide a movable instead of a fixed joint, e.g. Jones's operation or Murphy's arthroplasty. These should not be lightly entered upon. Their whole success depends on the most complete absence of infection, and this, in an old tuberculous hip, is not always to be relied upon, especially if sinuses have existed. Moreover, the great desideratum in the lower limb is stability; mobility is a poor second. In bilateral hip

Clinical types.—1. The variety described above is the commonest. In the early stages it is generally known as tumor albus. It is especially associated with diffuse thickening of the synovial membrane.

2. *Tuberculous hydrops* is a comparatively rare condition which can with difficulty be diagnosed from recurrent traumatic simple arthritis. It is associated with fluid effusion into the knee. Sometimes fibrinous "melon-seed" bodies can be detected.

3. *Localized synovial disease.*—This may either be a localized thickening of the synovial membrane over a part of the capsule, or it may take the form of one or more pedunculated tumours hanging into the joint. It is a rare condition. A variety of this form, sometimes known as Riedel's or Koenig's *nodular* form, is occasionally seen; it is unilateral, occurs in young children or adolescents, generally of the female sex, and is characterized by very insidious onset, nodular thickening of synovial membrane, especially in the subcrural pouch, plentiful effusions, free and painless movements, and absence of involvement of bone and cartilage until late in the disease.

4. *Empyema of the knee-joint.*—In this rare condition the joint becomes filled with tuberculous "pus." The infection is usually primarily synovial, and the subjects are much reduced in health. They are frequently sufferers from tuberculosis elsewhere.

Differential diagnosis. 1. *Acute traumatic arthritis* (simple). —Ten days or so in bed should clear up this condition. That amount of rest will not do so if the affection be tuberculous.

2. "*Internal derangement*" *of the knee-joint due to loose cartilage, etc.*—Here the history of sudden onset is of value, except in those rare cases where pedunculated synovial tubercles exist.

3. *Rheumatoid arthritis.*—The more acute pain and tenderness and the fact that this disease is frequently polyarticular may give guidance.

4. *Syphilis.*—In secondary syphilis a symmetrical, serous effusion into the knees may occur; it is quite painless. Periarticular gummata may be confusing. The nodular synovial form of tuberculosis has to be distinguished from gummatous synovitis. Wassermann's reaction is of some assistance here.

5. *Tumour growth* can usually, but not always, be readily differentiated by the help of X-rays.

Treatment.—In children conservative measures are worth an extended trial, partly because the results are better, partly because time is a secondary matter, and partly because operation is apt to interfere with the growth of the limb. In the lower limb most growth occurs at the knee-joint epiphyses, hence the advisability of delaying operation as long as possible.

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In adults conservative treatment should be tried, but when there are indications that the disease is progressing operation should be resorted to.

Conservative treatment is carried out on the lines already detailed. Fresh air, sunshine, good food should all be obtained, and fixation and extension applied. Hyperæmia on Bier's plan may be employed for one hour a day, in periods of five minutes' hyperæmia alternating with five minutes' release. As the condition improves, ambulant treatment may be instituted by the use of a Thomas knee-splint with patten on the boot of the sound foot (Fig. 861), and plaster-of-paris or celluloid splints. Injection of iodoform, etc., is easily carried out if such a practice be deemed necessary.

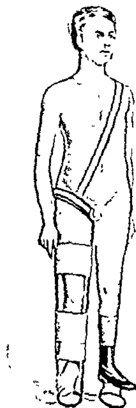


Fig. 861.—Thomas's knee-splint in use.

Operative treatment *is called for, especially in adults, where starting-pains, etc., indicate much destruction of articular cartilage, where, in spite of conservative treatment, the disease is getting worse, or where the general condition of the patient—phthisis, waxy disease, etc.—calls for removal of the knee focus.*

In patients who are still capable of growth, arthrectomy is the operation of choice. When the growth period is over, excision is to be preferred.

Amputation may be called for, especially in adults, when the disease has relapsed after excision, when long persistent discharge from chronic sinuses has produced waxy disease, or where the extent of the disease, as demonstrated by radiography, is so great that excision would leave an excessively shortened limb (a leg that is more than 4 inches shorter than its fellow is not of great use). Occasionally, too, the patient may be too enfeebled to withstand excision and its after-treatment, yet well enough to undergo amputation. When advancing tuberculosis is present elsewhere, removal of a diseased knee by amputation sometimes enables the patient to resist the other foci less amenable to abolition.

Operation should be resorted to for the treatment of deformed attitudes left after subsidence of the disease. The treatment of deformities resulting from ankylosis of the knee-joint in bad position is frequently difficult. Arthroplasty or osteotomy may be tried if gradual replacement by extension prove unavailing. For fixation in

excessively flexed position, excision may be done after all signs of active disease have long disappeared.

TUBERCULOSIS OF THE ANKLE-JOINT

If the popliteal artery be injected with pigment, a considerable quantity of the pigment is to be found in the neck of the astragalus (Fraser). The vessels which form the circulus vasculosus in this region are present in the neighbourhood of the neck of the astragalus, where synovial membrane is reflected from capsule on to bone.

It is frequently stated that primary osseous disease is exceptional in the ankle joint. Probably in the majority of cases the astragalus is involved. The morbid anatomy does not differ from that of arthrosteal tuberculosis in general.

Symptoms.—The early symptoms are usually some degree of pain, a readiness to tire, and a slight limp. Frequently subjective symptoms are entirely in abeyance, and an abscess may be the first sign of the disease. Usually swelling of a pulpy character occurs on the dorsal aspect of the ankle-joint, the extensor tendons being raised. Posteriorly the hollows on both sides of the tendo Achillis and below the malleoli are gradually obliterated. There is usually resistance to movement of the ankle-joint (extension and flexion), though gentle handling will often enable the surgeon to demonstrate mobility of the inversion and eversion that take place at the midtarsal joint. Abscess-formation is frequent. Mixed infection often occurs and sinuses readily form. The tendon sheaths in the neighbourhood may be invaded, and abscesses thus conveyed to more distant parts.

Differential diagnosis.—(1) Other forms of chronic periostitis, chronic osteo-myelitis, or arthritis. (2) New growths of bone. Radiograms, history of onset, and points of special tenderness may clear up the difficulty.

Treatment.—**Conservative** treatment on the usual lines should be tried. A plaster case or splint to secure immobilization should extend up to the tuberosities of the tibia and down to the toes. The foot should be fixed at right angles to the leg. The weight should not be borne on the diseased foot.

Operative treatment is indicated where the disease is advancing or suppuration has occurred. Arthrectomy combined with removal of the astragalus is the operation to be preferred. Excision may also be performed. Without removal of the astragalus permanent eradication of the disease is hardly to be expected. If amputation be found necessary, removal at the lower third of the leg may be performed.

Tuberculosis of the Tarsus

It is not easy to determine the order of frequency with which the bones of the tarsus are affected. Probably the os calcis is most often attacked, then the astragalus, the cuboid, and the base of the 1st metatarsal. It is fortunate that the scaphoid and cuneiforms are but infrequently involved.

The affected part of the foot becomes swollen, shiny, and tender, and movements, such as inversion and eversion, into which the diseased bones enter, become painful and restricted. Disease in the os calcis may be long confined to that bone; the patient walks on the toes, but movements of ankle and midtarsal joints may remain free. The synovial cavities of the outer row of tarsals being more isolated, disease in the constituent bones is likely to cause more limited extension and to be more tractable; on the other hand, extension from the inner column, in which there is freer communication between synovial sacs, is likely to be wider and more difficult to treat.

Conservative treatment is worth trying. Abscess-formation and the development of sinuses are not uncommon If one bone only be affected, that bone may be excised (e g. astragalus), or the interior of the bone (e.g. os calcis or cuboid) scooped out and the shell then swabbed with pure carbolic.

If there be extensive disease of the midtarsus, a block of bone comprising scaphoid, cuneiforms, cuboid, etc., may be removed. In many cases extensive involvement, especially of the bones and complicated synovial sacs of the inner column of the foot, requires amputation; in such cases a Syme's or, occasionally, a subastragaloid operation may be done.

If the disease be confined to the ankle and posterior tarsus, a von Mikulicz osteoplastic excision is occasionally done. The lower ends of the tibia and fibula are divided. The scaphoid and cuboid are sawn through transversely; the divided bones are brought into line, and the patient walks on the balls of the toes.

Tuberculosis of the Shoulder-Joint

Pathology. — Tuberculous disease of the shoulder-joint is most common during the third decade of life. It may, however, occur at any age. Statements vary very much as to the relative incidence in synovial membrane and in bone. Cheyne states that the disease is most often primarily osseous. Fraser, basing his results on the examination of children, states that it is primarily synovial, and any involvement of the bones secondary. When bone is attacked it is most frequently the head of the humerus that suffers first; the glenoid surface may be involved later.

The shoulder-joint is that in which the condition of caries sicca is most often found.

Symptoms.—Pain is frequently more pronounced in tuberculous shoulder than in similar affections of other joints. It is usually attributed to pressure on the nerves by the distended and thickened capsule, the musculo-spiral especially being involved. The other features of arthrosteal tubercle—swelling, rigidity, limitation of movement, and muscular wasting—are also present. In the advanced condition of the disease the arm is held close to the side and rotated inwards. Real shortening may occur. Abscess-formation is not uncommon, and the pus may burrow, appearing at the anterior or posterior fold of the axilla or in the axillary space. Frequently it follows the bursal protrusion along the biceps tendon and appears about the middle of the upper arm; this is probably the commonest site for the open mouth of a sinus leading from a tuberculous shoulder-joint.

Diagnosis. 1. *Rheumatoid arthritis.*—Sometimes difficult. There is generally less rigidity and more grating in rheumatoid arthritis; pain occurs in exacerbations, and is worse after rest.

2. *Neuro-muscular lesions.*—Here there is usually no pain. Movements are unusually free.

3. *Adhesions.*—There is less pain, especially when the patient is at rest; jarring of the arm does not provoke pain.

4. *Disease in the subdeltoid bursa.*—This does not usually affect the passive movements of the joint itself.

5. *New growths of the upper end of the humerus.*—A good radiogram is helpful.

Prognosis.—A rapid cure is seldom obtained. Several years may pass before the disease subsides. In children growth may be greatly impaired. There is usually a considerable amount of fibrous ankylosis which restricts the freedom of movement of the joint. This is often compensated by increased mobility between thorax and scapula.

Treatment. Conservative.—Rest and fixation are essential. The limb should be put up in the abducted position with elbow pointing forwards almost parallel with the median plane of the body. This may be accomplished by Robert Jones's abduction shelf splint or a wedge-shaped pad in the axilla combined with plaster-of-paris bandages. Extension may usefully be employed The patient usually refuses to lie in bed, nor is it advisable that he should do so continually. In this case the weight of the limb must be the main extending force.

Operative interference is frequently required. Excision may then be performed, gentle passive movements being begun early with a view to securing a mobile joint.

Tuberculosis of the Elbow-Joint

The age-incidence of tuberculosis of the elbow-joint is *comparatively* early, most cases occurring before the age of 30.

Bone is much more frequently than synovial membrane the original seat of the disease. In Stiles's series of 54 cases, 14 were primarily synovial, 40 were primary in bone. Of these 20 were humeral, 13 ulnar, 3 radial, while in 8 cases more than one bone was involved. Infection is metaphysial, and occurs via the circulus vasculosus.

But the condition is also to be seen in "senile struma," and then appears to be more frequently synovial in its early manifestations.

Symptoms.—The usual symptoms of a tuberculous joint are present. The joint, as a whole, looks fusiform, and the hollows at the side of the olecranon are filled up.

Limitation of movement occurs in regard to both flexion and extension. When the radius is involved, pronation and supination are restricted from the first. Otherwise this movement may persist for a short time until the superior radio-ulnar joint is involved.

Muscular wasting is an early sign, and throws into relief the articular swelling. Abscess-formation usually takes place beneath the triceps, and the abscess tends to come to the surface on either side of the triceps tendon.

Rarely, tuberculous hydrops is present with "melon-seed bodies" in the fluid. The joint is usually held at the angle of 120°–140°, *and fully pronated. This is an inconvenient position for ankylosis.*

Prognosis.—Resolution with complete restoration of function is rare. Ankylosis must always be anticipated. Abscess-formation is frequent. Pyogenetic infection should be avoided.

Treatment. Conservative.—Fix with plaster-of-paris or celluloid splints in a position rather less than a right angle, and with the hand supinated; a patient with elbow ankylosed in this position has more general use of his limb than in any other, *for he can* obtain sufficient pronation from his thoracico-scapular and other joints; the nature of the patient's *occupation must, however, be considered,* and the position modified accordingly.

Operative.—Interference is indicated with comparative frequency in the tuberculous elbow. An excised joint *may obtain very* good movement. In a joint treated conservatively ankylosis is the usual result; this often calls for excision later for the restoration of *mobility.* Mobility is the chief desideratum in the upper limb, hence *excision or arthrectomy is often* preferable. In children conservative measures are desirable, followed after the age of 17 by excision of the *cured ankylosed joint for the purpose of securing mobility; if more urgent* treatment is required during the active stage of the disease, *erasion should* be done rather than excision. In adults, on the other

hand, if conservative treatment fails, excision may be done at once. Amputation is very rarely required.

Tuberculosis of the Wrist-Joint and Carpal Joints

The infection is usually synovial. If it be primarily osseous, the focus is generally in the lower end of the radius or in the 2nd or 3rd metacarpal. Occasionally the disease is secondary to tuberculosis of the neighbouring tendon-sheaths.

Though young adults chiefly are affected, tuberculosis of the wrist is the most frequent form of arthrosteal tuberculosis in elderly people; it affects children and young people, but is also commoner in the elderly than is the case with tuberculosis elsewhere.

Symptoms.—The attitude is that of slight flexion with drooping of the hand and fingers. This is a bad position for ankylosis. The grasp of the fingers is weak and opposition of the thumb impossible. Pulpy swelling is present under the tendons, chiefly on the dorsum; in front there is also frequently swelling both proximal and distal to the anterior annular ligament.

Treatment. Conservative.—The wrist should be put up in distinct dorsiflexion, as this is the functional optimum position if ankylosed. The fingers should be left free and care taken, by passive movements, to preserve their mobility. Much patience and perseverance should be exercised.

Operative.—This is required if conservative measures do not *benefit the condition, or if the removal of the disease is urgently* required for other reasons. Excision may then be performed, but is unsatisfactory; a "set" excision often leaves a weak flail joint requiring support from a leather case; if operation is required, most surgeons are content to do a partial excision with removal of those bones most obviously diseased. Amputation is occasionally, but very rarely, indicated.

Tuberculosis of other Bones

Ribs.—Essentially an affection of adult life. The disease may be primary, or secondary to spinal disease. The lesion is usually a periostitis.

Symptoms are indefinite in the early stages. Later, abscess-formation occurs. The "pus" may bulge inwards towards the pleura, or track along the rib for a long distance from the original deposit and point outwards.

Treatment.—It may be possible to remove the affected segment of rib without opening the abscess. If so, this should be done. Eradication should be as thorough as possible. Drainage should never be used.

The **sternum** is not infrequently affected. The disease must be treated on general principles.

Tuberculosis of the **clavicle** is rare. Occasionally the acromial end is affected. The lesion is a periostitis or an osteo-myelitis. The diseased portion should be gouged or chipped away.

The **skull** is in rare instances the seat of tuberculosis. The frontal and parietal bones may be affected. The tuberculous infiltration begins in the cancellous tissue of the diploë; later it may chiefly affect the inner or outer table, especially the latter. Sequestra are common. A cold abscess forms under the pericranium; it may perforate *this membrane and spread through the scalp. Although there is* often some underlying pachymeningitis, general tuberculous meningitis is an uncommon complication. The condition must be diagnosed from syphilis; for this purpose the Wassermann reaction is of value. Headache, a frequent concomitant in syphilis, is infrequent in tuberculosis. In tuberculosis the sequestra are soft and crumbling, and there is no serious thickening of periosteum, though the subpericranial space may be filled with granulations; in syphilis, on the other hand, the sequestra are hard, the surrounding bone is thickened and its edges near the sequestrum are eroded. The **treatment** is essentially operative, and consists in removal of the diseased portion of bone.

The **mastoid** process is not uncommonly the seat of tuberculous disease, usually secondary to middle-ear disease. A radical mastoid operation is the treatment.

The bones of the **face** are the seat of tuberculosis less rarely than those of the skull. The lesion, which is usually periosteal, affects most often the orbital margin of the superior maxilla and the malar bone.

The **lower jaw** and the bones of the **nose** may become tuberculous, disease in the latter situation being frequently referred to as "*scrofulous ozæna.*" *Removal of the disease must* be as thorough as possible. One may have to remain satisfied with free scraping and subsequent cauterization.

Mĕtăcarpals, metatarsals, and phalanges (tuberculous dactylitis).—Tuberculosis of these bones is common in infancy and childhood. The disease takes the form of a tuberculous osteo-myelitis, and early involves the shaft of the bone. The central parts become eroded; at the same time new subperiosteal *bone is* laid down, so that a false expansion occurs

The part, whether finger, toe, or metacarpal region, slowly becomes swollen, spindle-shaped, tender and painful, and the affected bone is felt to be "expanc [illegible]
reddened and gives [illegible]
centre of the bone.

with, so that the ultimate result is a shortened finger or toe. Adjacent joints and tendon-sheaths may become secondarily involved.

Treatment in the first place calls for attention to general health, and fixation of the part in a position of rest; Scott's dressing may be of use if there be no reddening or threat of "pointing." Bier's congestive treatment may be used. If "pointing" appears, an incision should be made in such position as to avoid tendons, the centre of the bone gently curetted without undue damage to epiphysial lines, the cavity swabbed out with pure carbolic or with flavine, and the wound carefully closed. If closure cannot be maintained the cavity should be dressed with iodoform-paraffin emulsion or "Bipp," and allowed to heal by granulation.

SYPHILITIC DISEASES OF JOINTS

Although articular manifestations are uncommon in syphilis, relatively to the wide incidence of the disease, they are not infrequently seen, both in [illegible] The disease shows a decided pre[illegible]

[illegible] In the early secondary period arthralgia similar to the osteocopic pains in bones may occur, especially at night. There are no accompanying obvious physical signs.

(2) Slight or moderate synovial effusion with considerable pain may also be present at this stage; the condition is often bilateral, and especially affects the knees.

(3) In the later secondary period a much more chronic and generally painless variety of synovitis may appear; it is *frequently symmetrically bilateral*, and shows a special predilection for the knees. Rarely several joints are affected. The amount of effusion shows characteristically rapid and unexplained variations during its course. In some cases it is slight throughout, but in others it is so exaggerated that it justifies the term syphilitic hydrarthrosis. It is sometimes very resistant to treatment, and in rare cases quietly disintegrates the joint.

Tertiary.—(1) Diffuse gummatous infiltration of the subsynovial tissues and ligaments may occur and eventually lead to considerable thickening and disability due to cicatrization. There is usually some associated intra-articular synovial effusion, but this may be absent and is never excessive. The endothelial lining of the synovial membrane is intact. Movements are painless and comparatively free. Occasionally definite gummatous nodules are formed, which may break down.

(2) The bone-ends entering into the joint may be the seat of syphilitic change and periosteal new formation, both the epiphysis and the adjacent part of the diaphysis being affected. In these cases there is usually some secondary synovial effusion.

(3) In syphilitic chondro-arthritis the synovial membrane is thickened and its fringes are hypertrophied; the cartilage cells proliferate, its matrix fibrillates, and pitted erosions are formed which may extend down to the subjacent bone. No osteophytes develop; the erosion and eburnation of the bones are not extensive, and form pits rather than linear grooves. Any crepitus present is of a soft character, and pain is not a prominent feature. The pits are lined by degenerated gummatous material, or sometimes by

immature fibrous tissue. The synovial membrane may show gummatous change.

Congenital syphilis.—(1) The neighbouring joint may be involved in the syphilitic epiphysitis of infants under the age of 2 years. These cases react rapidly to treatment with grey powder. Suppuration occasionally, but rarely, ensues.

(2) A chronic hydrarthrosis may be seen, especially in older children, and particularly in girls near adolescence; it is quite painless, has a rapid, almost sudden onset, is often bilaterally symmetrical, and may be extreme in amount Movements are but little restricted. The underlying condition is a gummatous infiltration of the synovial membrane. It is commonest in the knees.

Interstitial keratitis is a frequent concomitant.

Treatment.—In cases arising in the secondary period, mercury and novarsenobillon [illegible]
For the later [illegible]
be given, wit[illegible]
the stage of the disease and the efficiency of the previous treatment.

The hydrarthrotic cases are often benefited by the use of Scott's dressings. Occasionally they resist treatment very obstinately; for those that progress to disorganization of the joint, excision may be recommended with very good prospects of a beneficial result.

It should be noted that the gummatous types show a definite tendency to recur.

PSEUDO-COXALGIA

Syn., Osteo-chondritis Deformans; Juvenilis Coxæ; Quiet Hip Disease; Coxa Plana; Caput Planum; Legg's Disease; Calvé's Disease; von Perthes' Disease.

During recent years this condition, at present afflicted with such a multiplicity of names, has been separated from tuberculosis of the hip, with which it was formerly confused. Hoffa, in 1903, had recognized a non-tuberculous arthritis of the hip in youth, but did not closely define it; Legg (1909), Calvé (1910), von Perthes (1910 and 1913), Legg (1916), Sundt (1921), and others have now definitely described the condition and separated it from tuberculosis.

Etiology.—It occurs most commonly in boys, especially between the ages of 5 and 9 years; *it is essentially a disease of the first* decade of life, and thus differs from the hip disability known as "slipped epiphysis," which is most often seen between 12 and 16. A history of recent, though possibly slight trauma is in many cases given.

Injury, rickets, syphilis, and congenital anomalies of ossification have all been wrongly blamed; but probably the underlying etiological factor is a low-grade infection with attenuated pyococci (*cf.* Schlatter's disease and Kohler's disease). I have recently had a case in which both pseudo-coxalgia and Schlatter's disease were present.

Pathology.—The characteristic changes, as seen with X-rays, are comparatively late ones. The femoral head becomes flattened and



Pseudo-coxalgia.

(By courtesy of Dr. R. W. Salmon.)

PLATE 140.

expanded laterally, its ossific nucleus becomes fragmented; the pieces ultimately fuse so that the head of the femur now develops into a permanently expanded and flattened cap encroaching, along the upper aspect of the neck, towards the trochanter. Simultaneously the neck of the bone gradually shortens and becomes considerably broadened. The acetabulum adjusts its shape to the altered form of the head, but the changes are not conspicuous. (Plate 110.)

Clinical features.—Platt arbitrarily divides the clinical features into three ill-defined stages, viz. (*a*) onset, (*b*) active stage, (*c*) stage of recovery.

(*a*) At the onset the symptoms suggest a *mild degree of synovitis*; they consist of muscular spasm, limping (which may be intermittent), slight and often ignored irregular fever, and, in about half the cases, pain in the hip or, perhaps, in the knee. The symptoms may begin abruptly or quietly.

(*b*) The active stage may endure from six to eighteen months, and includes the period during which active symptoms, other than the secondary results of the deformity, persist. Pain and tenderness fade away, and, later, muscular spasm is lost; during its presence the hip is often held fixed, flexed and adducted, not abducted as in early tuberculosis. When the general fixation due to spasm has gone, it is found that abduction, internal rotation, and, sometimes, flexion are still limited, probably because of continued local spasm, and, perhaps, shortening of adductors, and also from mechanical interference with articular movements due to the osseous changes. The limp becomes more intermittent and less obvious; it is never of exaggerated character. The trochanter is unduly prominent, and, according to Platt, is thickened. There is no localized wasting, but the whole limb is often inferior to its fellow in development. There is no mensurable shortening at this stage.

(*c*) In the stage of recovery the signs gradually disappear, but some limitation of abduction and, perhaps, trochanteric thickening may persist. Later in life a coxa vara deformity may emerge. Re-examination of radiographs and notes of past cases of claimed cure of tuberculous arthritis leaves little doubt that a certain number of such cases should have been diagnosed as pseudo-coxalgia.

The **prognosis** has already been indicated in discussing the clinical features; the tendency is strong towards cure, but slight loss of abduction may result, and coxa vara and osteo-arthritis may follow.

Treatment.—Immobilization of the hip during the active stages may shorten them; but the bony changes, once initiated, tend to continue through their appointed course. Phemister has explored the hip, but this is not recommended as a method of treatment.

ARTHRITIS DEFORMANS

An historical survey of the diseases that may be described under this heading leads to great confusion. Apart from the long controversy required to determine their separation from rheumatism and pure gout, their classification is complicated by the presence of many cases *transitional between rheumatoid arthritis and infective* (or toxic) arthritis, by the occasional coexistence of osteo-arthritis and rheumatoid arthritis, or of gout *and osteo-arthritis, in the same* patient, and by the confusion between rheumatoid arthritis with an acute onset and true rheumatism followed by chronic rheumatoid changes. The difficulty is increased by the diversity of nomenclature adopted by different authorities, by the impossibility of making these exactly synonymous, and by the failure to differentiate between rheumatoid arthritis and osteo-arthritis.

In chronic arthritis generally certain clinical and pathological processes may be discerned, namely, (*a*) atrophy, (*b*) hypertrophy, (*c*) synovial and periarticular thickening, (*d*) effusion, (*e*) plastic and adhesive changes.

*In some cases the atrophic elements and the synovial and peri-*articular fibrosis predominate, as in rheumatoid arthritis; in others, such as osteo-arthritis, hypertrophic changes form the most striking part of the picture, although at other parts of the joint atrophy is also present It is difficult to classify this group of chronic arthritides so as to delineate clearly the boundaries between its constituents; moreover, both rheumatoid arthritis and osteo-arthritis are not themselves really diseases but are pathological manifestations in the joints of the effects either of toxins of low or moderate intensity (as in *rheumatoid arthritis and probably in some cases of osteo-arthritis*), or of repeated traumata of slight or medium degree (as in many cases of osteo-arthritis) In the present state of knowledge, therefore, the definitions given must be regarded as largely empirical; they do not rest on a firm pathological basis, but correspond to a clinical differentiation of types of cases recognized by many clinicians. Until the relationship of the varieties of arthritis deformans is more thoroughly cleared up, the definitions given below may serve as a basis for description. I have taken *rheumatoid arthritis* to include cases of a *slowly progressive, generally symmetrical, crippling polyarticular disease* of toxic origin, with acute, subacute, or insidious onset, leading to thickening of the soft parts, including the synovial and subsynovial tissues, to atrophic changes in cartilages, tendons, muscles, and bones, and, unless appropriate prophylactic measures be taken, to fibrosis of involved soft parts, contractures, and deformities; osteophytic new formation is absent or slight in degree. *Osteo-arthritis*, on the other

hand, is a more localized monarticular or oligo-articular condition in which hypertrophic changes predominate, especially near the margins of the bones constituting the articulation, although atrophy is also present, particularly in those parts of the bones and cartilage near the centre of the joint; it is characterized by osteophytic formations at the margins, and by atrophy, groovings, and eburnation nearer the centres, and perhaps by the presence of Heberden's nodes elsewhere. Persistent action of toxins of low virulence in some cases, frequent small traumata in others, appear to be etiological factors; or sometimes the condition follows severe trauma, although possibly in many such cases it is not the primary serious injury that causes the osteo-arthritis, but rather the multiple effects of consequent abnormal strains, associated with the resultant deformity.

For descriptive purposes I shall adopt the following classification fully recognizing, however, that further knowledge will probably demand its revision.

Arthritis deformans.

1. **Rheumatoid arthritis.**

    (Polyarticular—infective in origin—atrophic processes predominant—subsynovial and capsular infiltration.)

    (*a*) With acute or subacute onset.
    (*b*) With chronic onset.
    (*c*) Still's disease.

2. **Osteo-arthritis.**

    (Rather hypertrophic than atrophic, and possibly a degenerative process.)

    (*a*) Monarticular, including morbus coxæ "senilis"
    (*b*) Polyarticular or oligo-articular.
    (*c*) Cases associated with Heberden's nodes.

3. **Spondylitis deformans.**

RHEUMATOID ARTHRITIS

Definition.—As given above (p 946).

Etiology.—The age of onset may be any time between early childhood and old age, but is most often between 20 and 40; it is rather later in male than in female patients. Early cases tend to include the more acute forms

Statistics of *sex-incidence* vary owing to confusion of nomenclature, but there appear to be 3–5 female victims to each male.[1]

The patient's family history and occupation present no special etiological relationship.

The onset may be associated with any cause of *depression of the general health*, such as deficient nutrition, prolonged anxiety or overwork, or exposure to damp and cold, either habitual or on a specific occasion.

[1] Females—77 per cent., Garrod; 83 per cent, Llewellyn Jones; 72 5 per cent., Strangeways and Burt.

The relationship to changes and disease in the *female reproductive system* is frequently noticeable; the onset often coincides with puberty, the menopause, puerperal disorders, a miscarriage, prolonged lactation, leucorrhœa, or uterine disease.

The history of a single *trauma* or of repeated small articular injuries is frequently, but not at all invariably, elicited; Sutton and Arbuthnot Lane attributed much importance to this mechanical wear and tear, but it probably has more bearing on osteo-arthritis than on rheumatoid arthritis.

Although the previous health has often been good, a large proportion of patients have suffered from antecedent *infective diseases* such as influenza (the most frequent), gonorrhœa, measles, scarlet fever and other exanthemata, erysipelas, tonsillitis.

Oral sepsis, carious teeth, pyorrhœa alveolaris are frequent and potent factors; many severe but comparatively early cases *have been cut short* by efficient dental and oral treatment, which should include a systematic search for buried roots and for infected material under fixed dental crowns and bridges; in all cases of doubt, radiographic films should be taken of suspected tooth-fangs.

Alimentary disturbance, such as tonsillitis, gastric or intestinal ulceration, dyspepsia, or chronic diarrhœa, may be associated with the disease, and the patient may show other signs of gastric intestinal toxæmia. I have seen the development of rheumatoid arthritis immediately after ptomaine poisoning. Herter found abnormal intestinal putrefaction, evidenced by indicanuria, and, with others, emphasizes the etiological significa[illegible]

[illegible] described as sequels to true rheumat[illegible] [illegible]ese cases the primary polyarthritis was not true rheumatism but an acute onset of rheumatoid arthritis. In four of Llewellyn Jones's cases, however, there had been associated chorea. Moreover, cardiac valvular lesions have in a few rare cases been noted as commencing during rheumatoid arthritis.

The influence of previous *gonorrhœal rheumatism* is probable in many cases; it is interesting here to note that radiograms of gonorrhœal rheumatism may show areas of atrophy in bone-ends not dissimilar from those in rheumatoid arthritis.

Anæmia is probably secondary to, and not a cause of, the disease. *Bacteriological examination* has been disappointing; in many cases no organisms can be grown from either the synovial fluid or the periarticular tissues. Organisms have been described by Max Schuller (a bipolar, short, thick bacillus), Bannatyne and Wohlmann, confirmed by Blaxall (a minute, gram-negative, bipolar bacillus), Chauffard and Ramon (a short, thin, gram-positive diplobacillus), Fernet and Lacapère (the pneumococcus), Poynton and Paine (a diplococcus), Warren Crowe (staphylococcus), and others, but none has been definitely accepted as the specific cause. Probably the disease may be caused by the toxins of many organisms, and it is unnecessary to assume the presence of a specific microbe.

Senator, Ord, Duckworth, Spender, and others considered the disease due to a *neurotrophic disturbance*. Anterior cornual cell degeneration (Mott and Tredgold) and peripheral neuritis have been found, but are probably secondary.

The true pathogeny is yet unknown, although of recent years strong evidence has accumulated in favour of the microbic-toxic theory (3 (*a*)). The theories in the field are:—

1. *Neurotrophic*: probably incorrect.

2. *Microbic*, due to a local infection with—
   (*a*) A specific organism.
   (*b*) A variety of organisms.
3. *Toxic*, due to absorption of—
   (*a*) Microbial non-specific toxins from the mouth, teeth, alimentary canal, genital tract, or elsewhere.
   (*b*) The poisons of influenza and other infective diseases.
   (*c*) Toxins associated with disturbance of normal secretion of alimentary glands or with abnormal intestinal putrefaction.
4. *Infective neurotrophic*, which supposes the action of toxins through the nervous system.

In favour of the *bacterial* and *toxic* theories are :—

1. The frequent association with influenza or other infective disease.
2. The sweating often seen.
3. The secondary anæmia.
4. The presence of similar atrophy in gonorrhœa, a known infective disease.
5. The frequent association with gastric intestinal disturbance.
6. The improvement that often follows the discovery and treatment of a distant infective focus such as pyorrhœa
7. The associated thyroid enlargement sometimes seen, and the improvement of some cases treated with thyroid extract. Many cases of goitre are supposed to have an infective origin.
8. The indicanuria sometimes found.
9. The presence of enlarged lymphatic glands in some cases.

The following points in favour of the *neural* theory have been adduced, but they can practically all be explained on a toxic basis :—

1. Possibly the relation to puberty and menopause.
2. Changes sometimes seen in the spinal cord, though these may be secondary to toxæmia or to disuse of the parts innervated thence.
3. The muscular spasms at the beginning, though these may be due to the hyperthyroidism sometimes found in the earlier stages before hypothyroidism begins, or may be toxic, as in tetanus, etc.
4. The relation to depression and worry.
5. The frequent association with neuralgia, though this is very probably toxic.
6. The correspondence of many prodromata and some lesions to a spinal segmental innervation.

Morbid anatomy.—The morbid anatomy of the early and active stage of the disease has comparatively rarely been described ; most writers have only described the changes seen in the later and more passive period—the period of "sequels."

Early.—The disease is at first confined to the synovial membrane and periarticular soft tissues. The membrane is reddened, is considerably swollen, shows hypertrophy of its villi and fringes, and looks velvety. There is much round-celled proliferation and infiltration, which is later converted into a periarticular fibrosis. (In osteo-arthritis, on the other hand, the cellular increase is rather of the cells that normally occur in the part.—Timbrell Fisher.) Effusion may be absent or comparatively slight.

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The articular cartilage is at first not eroded, but is invaded from the periphery by a pannus of granulation tissue derived from the synovial membrane and its thickened fringes. This spreads over the surface, invades and erodes the cartilage; eventually in severe cases it joins with protrusions of vascular connective tissue from the bone into the deeper layers of the articular cartilage (Nichols and Richardson, Strangeways). There is no cartilaginous lipping at the edges. The cancellous spaces of the bone-ends are unusually open and are infiltrated with small round cells. A similar infiltration may be found under the synovial membrane and near the tips of the villi.

Later.—The synovial membrane and periarticular structures become progressively thickened and eventually contract. Synovial fringes and villi are much hypertrophied; new blood-vessels may form in them, and even nodules, fibrous or cartilaginous. Fat is often deposited in the fringes, even to such a degree as to justify the term lipoma arborescens.

The cartilage softens and degenerates; where pressed upon it becomes fibrillated and necrotic; its cells do not proliferate. Later it becomes eroded and perforated, exposing the subjacent bone. The cancellous bone is rarefied, its trabeculæ attenuated, and its marrow fatty. Even the cortex of the diaphysis is often thinned.

The rarefied extremities of the bones atrophy where pressure exists, and therefore become deformed. The periarticular contractures, ligamentous and muscular, throw abnormal strains on the weakened bone-ends, further asymmetric atrophy follows, and deformity often becomes exaggerated. Intra-articular fibrous adhesions are common. Where cartilaginous erosions permit exposed areas of cancellous bone to come into contact, true bony ankylosis may occur; this differs from the interlocking of osteophytes seen in osteo-arthritis.

Neighbouring muscles atrophy and may become contracted; intra-articular tendons and ligaments may entirely disappear; thus the scapular tendon of the biceps may become lost in the shoulder, and form a new attachment to the bicipital groove of the humerus.

The new osseous and cartilaginous outgrowths characteristic of osteo-arthritis are absent. Occasionally—especially if sclerosis of the capsule, and therefore immobility, are not prominent features—the bone throws out some spicules in an attempt at repair, but they differ from the rounded and more prominent osteophytes of osteo-arthritis.

The overlying skin frequently shows atrophic changes and is smooth, shiny, and cold.

In other organs, such as the heart-valves, vessels, liver, pancreas, and kidney, fibrosis has been found;[1] but these changes are all

[1] Katherine Clark, quoted by Llewellyn Jones.

very common, and their association with the arthritis is, to say the least, very doubtful. Degeneration of the anterior cornual cells, peripheral neuritis, and spinal meningeal changes have been noted in isolated cases.

Clinical features. Prodromal stage.—Before the appearance of the articular lesions, muscular, vaso-motor, and sensory changes may be noted in many cases In the *motor* system there may be premonitory muscular spasms, myotatic irritability, loss of power, and even muscular atrophy. *Vaso-motor* changes, such as localized sweating, especially in the palms, soles, dorsa of the feet and fronts of the legs, and coldness and blueness of the extremities, alternating sometimes with white "dead" fingers, may attract attention. Preliminary *sensory* phenomena take the form of paræsthesiæ in the limbs, and of pains which, like those of the active disease, fall under one of the three headings—neuralgias, persistent gnawing pain, or painful muscular cramps. Sciatica is common, especially in the upper part of the nerve. The tendon reflexes and superficial reflexes are exaggerated.

These prodromal symptoms are not always obvious, but all tend to continue through the active period of the disease.

The **onset of the active articular lesions** may be acute, subacute, or insidious. The *acute* form occurs chiefly in young women and is uncommon. Polyarthritic swellings rapidly occur, accompanied by a rise of temperature even to 103° F. In the *subacute* form the pyrexia is less and the polyarthritis slighter. These cases tend to progress by a series of exacerbations separated by quiet apyrexial intervals, during which, however, there may be muscular cramps and vaso-motor spasms. Eventually the pyrexia disappears, but the periarticular and articular changes persist and the disease becomes generalized. The type with *insidious* onset is frequently associated with the menopause and with mental depression and irritability. It is apyrexial and slow but ruthlessly persistent.

Active stage.—The *articular lesions* are those described above (pp. 949-50). The joint becomes swollen and fusiform, and may show an apparent depression over the joint line; the overlying skin is shiny and white or bluish. The swelling usually feels tensely elastic; occasionally, however, it is softer and may even give a false impression of fluctuation. There is usually no excess of intra-articular fluid, though sometimes in the knees it may be considerable and fill the communicating bursæ. The rubbing of opposed hypertrophied villi and fringes may, especially in the knee, cause a creaking sensation. Thickened fringes may be caught between articular surfaces and produce the symptoms of a loose body in the joint. They may sometimes be palpated, but no cartilaginous or bony outgrowths

can be felt. The radiographic phenomena are discussed on p. 954, and also in Vol. I., p. 668.

Distribution.—There is a strong tendency to a symmetrically bilateral distribution of the joint lesions. The changes, once initiated, are persistent. The disease usually begins in the hands and feet, and extends up the limbs. The metacarpo-phalangeal and mid-phalangeal joints of the hand or, less often, similar joints in the foot are usually the earliest victims. The wrists, ankles, elbows, and knees commonly are affected later. The temporo-maxillary and cervical vertebral articulations are affected with a frequency that is almost pathognomonic, although they may sometimes be attacked in osteo-arthritis and in gonorrhœal rheumatism.

Non-articular phenomena of the active stage.—Pyrexia is absent

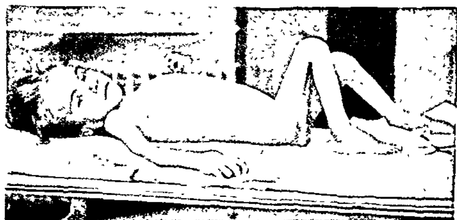


Fig. 862.—Rheumatoid arthritis in a child.
(By courtesy of Dr J Porter Parkinson)

in the chronic variety, but may reach 102°–103° F. in the acute or 99°–101° F. in the subacute forms; in both types active pyrexial periods alternate with gradually lengthening quiescent apyrexial intervals.

Tachycardia is a common and perhaps a very marked phenomenon; its persistence is an indication that the disease is still active (Ll. Jones); the pulse may maintain a rate as high as 130–140.

The muscular cramps, feebleness, and wasting persist from the prodromal stage, and the spasms tend to cause the limb segments to adopt characteristic attitudes (*see* p. 953) of malposition, which later still are exaggerated and fixed by contractures. A tremor is sometimes seen, and during the active stage myotatic irritability is increased.

Muscular atrophy progresses, often to an extreme degree (Fig. 862), especially in the extensor and interossei muscles and in the thenar

eminences; the wasting occasionally is general and affects the face, thorax, and abdomen as well as the limbs.

Vaso-motor symptoms, similar to those of the prodromal period, persist and may become greatly exaggerated. Sweating, at first general, but later localized especially to the palms, soles, dorsa of the feet, fronts of the legs, and backs of the forearms, is often a striking feature.

Patches of brownish or yellowish pigmentation (Spender's patches) may appear anywhere, and are sometimes very noticeable on the face.

Subcutaneous fibroid nodules may be found near the diseased joints and also in the palmar and plantar fasciæ. They occur at a later age than those of rheumatism, and are more tender and more persistent (Garrod).

Lymphatic glandular enlargement is found in some adult cases (belonging to the definitely infective type), as well as in Still's disease of children.

Later stages: the period of "sequels" (Garrod).—The active disease may cease and the patient remain comparatively comfortable and uncrippled. Too often, however, sequels occur. The joints shrink, their skin becomes smoothed, thin, and bluish-white, and the fingers are shortened and useless. The vaso-motor changes and hyperidrosis disappear, leaving the skin dry. Occasionally, however, the lower limbs show a solid elephantoid œdema with dry, rough skin. All the articular elements—ligaments, cartilages, and bones—atrophy, sometimes to an extreme degree.

The periarticular tissues and muscles become contracted in the abnormal positions due to the spasms, the bone atrophy becomes exaggerated, and even subluxations may occur. Intervening cartilage may entirely disappear and true bony ankylosis result. The strongest emphasis should be laid on the fact that these sequels are not inevitable; most, or all, of them can be prevented by rational treatment during and after the more active stages and by intimate co-ordination between surgeon, physician, and masseur.

Charcot classified the digital distortions in great detail under two main headings, viz.: (a) the flexion type—flexion of the distal interphalangeal, metacarpo-phalangeal, and wrist-joints, with extension [illegible] e extension [illegible] metacarpo- [illegible] langeal and wrist-joints: but these types are very frequently mixed.

Ulnar deflection of all the fingers is the rule, sometimes accompanied by radial declination at the proximal interphalangeal joints. Rarely, radial adduction of the fingers is seen.

Radiograms of the joints may show no obvious change. Fre-

quently, however, appearances such as those shown in Plate 141, and in Vol. I., Plate 49, Fig. 4, are seen. As the cartilage atrophies, the normal translucent band between the bones is diminished. Bone atrophy is shown by undue translucency of the cancellous tissue, reduction and attenuation of the trabeculæ, and perhaps by thinning of the compact bone of the shaft. In some cases that, according to Strangeways, fall under the category of rheumatoid arthritis, there are localized rounded translucent areas like those seen in chronic gout, but on dissection revealing erosions filled with gelatinous material. As cartilaginous and bony atrophy progresses, the joint line becomes distorted, the bones are shortened, and the characteristic deformities and perhaps subluxations appear. Such deformities and subluxations should, however, be regarded as sequels that should be prevented.

Ankylosis may be obvious, especially in the carpus and tarsus, and outlines of the bones become confused.

Diagnosis.—Acute or subacute *true rheumatism* may be confused with the more acute forms of rheumatoid arthritis; it may be distinguished by the involvement of larger rather than of smaller joints, by the immunity of the temporo-maxillary and cervical articulations, by the marked pain and tenderness, the greater degree of synovial effusion, the profuse general sweating, the frequent cardiac complications, and the therapeutic reaction to salicylates. The articular swellings lack the persistency of those in rheumatoid arthritis, and tend to flit from joint to joint. Muscular wasting, pigmentation, vaso-motor and trophic changes are slight or absent.

Gonorrhœal rheumatism prefers to attack larger joints, especially the knees, and is common in non-articular ligaments and fasciæ; these facts, with evidences of gonorrhœal urethritis, or of present or recent iritis or other ocular inflammation, will generally lead to a diagnosis. Occasionally, however, gonorrhœal rheumatism is to be seen in interphalangeal joints; then the spindle-shaped swelling mimics rheumatoid arthritis very closely.

Osteo-arthritis may usually be distinguished by the presence of definite osteophytic new formations, well seen in radiograms, by the greater age of the patient, by the relatively greater frequency in males, the less generalized and frequently asymmetrical distribution, and by its predilection for larger joints. Moreover, pain and muscular spasm are not so prominent as in rheumatoid arthritis

Chronic gout frequently presents a characteristic gouty past history, often commences in the great toe, and especially attacks middle-aged and elderly males. The radiograms sometimes closely resemble those of rheumatoid arthritis, but sometimes rounded translucent areas are seen in the bone-ends. The presence of tophi in knuckles, ears, etc., will sometimes indicate the gouty nature of the complaint.



Rheumatoid arthritis commencing in the puerperium in a woman of 24.

PLATE 141.

The **prognosis** is distinctly unfavourable, but, if the disease be recognized early, not at all hopeless. In the later stages many of the subjective pains disappear, but the limbs may have, from improper treatment, been allowed to become crippled and distorted; only amelioration can then be expected. In some of the most acute cases the patient rapidly becomes miserably bedridden and helpless, and eventually dies of some intercurrent affection. Llewellyn Jones regards persistence of tachycardia, vaso-motor phenomena, sweating, and myotatic irritability as evidences of continuance of the underlying toxæmia and as grave prognostic omens.

Much depends on the patient's ability to obtain good nourishment, prolonged and skilful treatment, and freedom from anxiety.

Treatment.—During the earlier stages general and local measures must be adopted to remove any discoverable cause, to reduce pain, swelling, and stiffness, and to re-establish the general health. The two chief principles are (1) to "*de-stress*"—to prevent stresses and strains and pressures on the cartilages, ligaments, and other affected articular elements; and (2) to put the joints regularly, but as painlessly as possible, through their full range of *movements*. In the stage of so-called sequels treatment is directed to governing and *minimizing crippling*.

Inculcation of cheerfulness, removal of anxiety, residence in a dry, warm, equable inland climate, wearing of warm but light clothing, and supply of nourishing, digestible food are all important. The *diet* must be as generous as the patient's digestion permits. In the acute stages and during exacerbations little can be given but milk, albumin water, plasmon, Benger's food, and similar preparations. Fats such as cream or cod-liver oil and malt are indicated unless they cause indigestion. During quiescent intervals liquid paraffin (½ oz. t.d.s.) or petroleum emulsion may be given, and the diet enriched by the addition of boiled white fish, milk puddings, eggs, fresh minced meat, chicken, and perhaps some stout or burgundy.

In the chronic stages the dietary should be digestible but bountiful, and especially rich in fats. Meat should not be withheld unless intestinal putrefaction is marked. Rest in bed is necessary during exacerbations, but gentle passive movements should be undertaken early to minimize stiffness. At other times the patient should be urged to take gentle exercise in the open air.

Encouragement of excretion by attention to the bowels, by renal flushing with large diluent drinks, and by bath and spa treatment is advisable.

Every focus from which toxæmia may be derived must be treated. The mouth, nose, accessory sinuses, tonsils, genito-urinary tract, and intestines should especially be suspected. The teeth and gums

should be carefully treated and intestinal fermentation attacked. In some early cases of mine the use of vaccines prepared from the predominant organisms found in tooth-sockets has proved of distinct value in arresting the disease.

On the whole, *drugs* are disappointing. Quinine may be exhibited in the acute stages, and a mixture of aspirin, phenacetin, and caffeine used to alleviate pain. Later, guaiacol carbonate, potassium iodide, syrupus ferri iodidi, and arsenic may be used, or intestinal antiputrefactives such as β-naphthol, salol, carbolic acid, or liquid paraffin administered. In some cases (according to Llewellyn Jones, especially those with marked vaso-motor symptoms) the exhibition of thyroid extract has proved of value.

Locally, complete rest is helpful during the painful stages, with in some cases the application of extension to prevent the onset of contractures. In the more chronic stage, rubbing with lin. pot. iod. cum sapone, and massage, with passive movements and active movements against gentle resistance, are advisable. Every effort must be made to prevent stiffening and to control distortion.

Great relief from pain, swelling, and stiffness may be obtained by active hyperæmia, induced by surrounding the joints with dry hot sand, or by subjecting the patient to a course of hot-air baths (Tallermann's) or radiant-heat baths (Dowsing's). The use of "medical" diathermy for warming the tissues of the part is sometimes helpful. Relief of pain and temporary general improvement sometimes follow passive hyperæmia by Bier's bandage method. The application should be tight enough to cause venous obstruction and even some œdema, but not to alter the arterial pulse or to cause pain. Bier recommended its use for twenty-two hours in the day, but this is quite unnecessarily long.

In many cases, but particularly in monarticular cases in the lower limb, much benefit is derived from the application of the principle of preventing interosseous pressure by the wearing of a comfortable "de-stressing" splint, such as a Thomas calliper. At the same time the principle must be followed of putting the joint regularly through its full range of movement, to prevent contractures. These two principles far outweigh in importance the somewhat empirical medical and thermal methods of treatment.

In the early quiescent periods, spa treatment by thermal, peat, or volcanic-mud baths, massage, douche massage (Vichy method), large hot draughts, and an enforced régime claims many good results. Buxton, Bath, Harrogate, Strathpeffer, Aix-les-Bains, and Plombières are among the many suitable spas. The Plombières method of high intestinal lavage may be a useful accessory.

Electrical treatment may take the form of cataphoresis with

iodine or chlorine, of electric baths or cells, or of the passage of a continuous current from a + electrode placed on the affected joint.

In the *stage of sequels* splints may be necessary to control contracture; but encouragement of movement is even more important. Both active and passive movements must be practised.

Distortion must be avoided or corrected by passive movements, accompanied, if necessary, by tenotomy. Greatly hypertrophied fringes may occasionally require operative removal. In cases of severe contracture, where the disease is quiescent, capsulotomies may be performed and other orthopædic operations undertaken, often with considerable benefit.

Fibrolysin, at one time much vaunted, is useless.

STILL'S DISEASE

Ordinary rheumatoid arthritis may be seen in children (Fig 862), and an occasional case of the disease in adults may present lymphatic enlargements; but Still descr
of the second
matoid type.
numerous joint
and painless enlargement of lymphatic glands, and frequently by splenic hyperplasia.

The onset is often insidious, and in many cases occurs in the knees, ankles, wrists, and neck, the course is slowly progressive, though occasionally there are periods of quiescence, or even of temporary improvement. Numerous joints, including those of the hands, become successively and symmetrically involved. Sweating is marked, some polymorphonuclear leucocytosis may be present, and the temperature may continue up to 100° or 101° F., though usually there are apyrexial periods.

The joint changes consist chiefly of synovial and periarticular thickening, with sometimes slight intra-articular effusion. Later the cartilages become pitted by synovial processes, but are otherwise healthy. The bones escape and bony ankylosis does not occur. There is no suppuration Muscular atrophy is marked, and contractures may be present. Whitman has recorded an association with enlargement of the liver.

The **prognosis** is bad, but one or two recoveries have been recorded.

Treatment follows the lines laid down for rheumatoid arthritis. Whitman treated one case by arthrotomy and lavage, with recovery.

OSTEO-ARTHRITIS

Osteo-arthritis is a localized or a generalized disease characterized by predominance of hypertrophic changes in articular cartilages and bones, by osteophytic formations, and perhaps by Heberden's nodes.

Etiology.—The true pathogeny is as unsettled as that of rheumatoid arthritis
bination of
and tear, o
and other signs of tissue ageing. The influence of abnormal strains and multiple traumata is illustrated by the frequency with which osteo-arthritis

supervenes in joints that, owing to old injury or disease or abnormal shape, have habitually been used in faulty attitudes; thus a patient with adolescent coxa vara is liable to osteo-arthritis in the affected hip later in life.

Some writers have considered the degeneration primarily a vascular one; the association *pari passu* with a corresponding degree of vascular alteration is not frequent. Timbrell Fisher found that in the early stages there is an increased vascularity of the synovial membrane.

The analogies of the articular lesions to those seen in the neuropathic arthropathies of tabes, syringomyelia, etc., have led others to attribute the degeneration to a neural cause; but no central nervous lesions can be demonstrated.

An infective origin has been suggested, but no micro-organisms have been found. Poncet and others have regarded the condition as one due to the circulation of attenuated tuberculous toxins Lastly, an alteration in the internal secretion of some ductless gland has been blamed. As predisposing causes, age, exposure to damp and cold, a trauma, a series of jars or strains, are undoubted factors.

Morbid anatomy.—Cartilage and bone are first attacked, but eventually no articular element escapes.

The articular *cartilage* becomes softened and lustreless, and its matrix fibrillates. The cartilage cells multiply; according to Cornil and Ranvier, those abutting on the articular cavity burst their capsules and are lost, probably into the joint: hence the cartilages wear away and expose the bone-ends; those at the edges, protected by synovial membrane, do not escape, but proliferate to form chondrophytes which ossify into osteophytes. Similar outgrowths sometimes develop in the capsular ligaments, possibly from the small cartilaginous metaplastic deposits not infrequently found in the subsynovial layers.

The exposed *bone* becomes polished and ivory-like (eburnated), and presents a hard-looking but thin, smooth articular face pitted with Haversian canals (Fig. 863.) Further attrition produces a series of grooves parallel to the movements of the joint.

At the same time the peripheral osteophytes increase in number and size, and cause an appearance similar to that of the guttering of a candle. Their exaggeration, combined with the central wearing, produces a rough mushroom shape at the bone-ends. (Fig. 864.)

The compact bone of the diaphysis may be thickened and sclerosed; but in the senile type, at any rate, the cancellous bone tends to become attenuated. Sometimes apparent absorption may occur; for example, *the femoral neck may be greatly* shortened and its angle with the shaft narrowed; probably, however, this is not due to true interstitial absorption, but to attrition.

True bony ankylosis does not take place, but the joint may be locked by fast dovetailing of osteophytes.

The *synovial membrane* shows hyperæmia, connective-tissue cell

proliferation, villous hypertrophy, and perhaps considerable fatty increase; later it undergoes mucous and hyaline degeneration (Hoffa). Synovial chondromas and osteo-chondromas are common features. Intra-articular *menisci* and *ligaments* disappear; so do trans-articular *tendons*, such as the long biceps tendon, which may develop a fresh humeral attachment below the shoulder.



Fig. 863.—Osteo-arthritis of hip (morbus coxæ senilis).

Attrition and eburnation of the articular surfaces are well shown, also the osteophytic "guttering" *at the edges. Same specimen as in Fig. 864, disarticulated.*

(Dreadnought Hospital Museum, Greenwich.)

Pedunculated or detached villi, chondrophytes, or osteophytes may give rise to recurrent signs of a *loose body* in the joint.

Non-articular organs and structures show no special changes.

Clinical features.—The *patient is usually beyond middle age*, but may be young, and even in rare cases still a child. The disease may be generalized or localized to one or a few joints: the latter variety shows some predilection for males; the former is common in females.

Large joints, especially in the localized form, are liable to a degree not seen in rheumatoid arthritis. The disease may commence in several articulations, but progress chiefly in one, or may appear in one large joint and then spread to others. The changes are not seldom bilaterally asymmetrical.



Fig. 864.—Osteo-arthritis of hip.

There are marked "mushrooming" of the head and shortening of the neck of the femur, with interlocking of the joint.

(*Dreadnought Hospital Museum, Greenwich*)

The onset and progress are always slow and insidious, and unaccompanied by much constitutional disturbance. The patient complains of stiffness and some aching pain, especially on movement after rest. Severe pain is usually absent unless, as sometimes in the hip or spine, pressure by osteophytes on nerves causes sciatica, anterior

crural or intercostal neuralgia. Crepitus, either creaking or grating, and even clicking, is often present, and may be distinctly audible.

The joint may at first be swollen with intra-articular fluid, but it does not show the fusiform shape due to periarticular swelling. Later the effusion tends to dry up, and the enlarged bones, knobby osteophytes, and hypertrophic fringes may be felt. Occasionally the synovial effusion is persistently excessive and may cause ligamentous laxity and articular weakness; in such cases Baker's cysts (*see* p. 878) may form. The bony excrescences, by their size and position, may produce considerable deformity, and perhaps displacement in a lateral direction, but the contractures characteristic of late rheumatoid arthritis are absent. There is no localized hyperidrosis, pigmentation, vaso-motor changes, or enlargement of lymphatic glands; muscular atrophy is usually slight, and the skin over the joint is unaltered. In the generalized form the hands often suffer; the joints are knobby and not shrunken; whilst Heberden's nodes (*see* below) are frequently found around the terminal interphalangeal joints, which are rarely attacked by rheumatoid arthritis. Garrod states that osteo-arthritis has a special predilection for the metacarpo-phalangeal joints of the thumbs.

The temporo-maxillary articulations may be affected, but less often than in rheumatoid arthritis; the changes may be unsymmetrical, and the mandible pushed forward and to one side.

Radiography may show—

(*a*) Bony excrescences and guttering round the edges of the joint.
(*b*) Mushroom shape of the heads of the bones.
(*c*) Increased density of the compact shell of the shaft.
(*d*) Distortion of joint surfaces.
(*e*) Narrowing of the translucent band normally occupied by articular cartilage.
(*f*) Interlocking of osteophytes rather than bony union.
(*g*) Sometimes rounded areas of undue translucency near the heads of the bones are important signs of osteo-arthritis; they often appear early; they may take the form of pseudocystic spaces traversed by attenuated trabeculæ.
(*h*) Heberden's nodes (*see* below).
(*i*) Bruce's nodes, small bony outgrowths at the sides of the phalangeal shafts.

Osteo-arthritis in special sites.—(*a*) *Heberden's nodes* are small, gradually enlarging, bony lumps, visible also by radiographic methods. They are periosteal in origin and do not necessarily involve the joint itself. They are especially found near the terminal interphalangeal joints, and tend to be bilaterally symmetrical in distribution and to involve all the fingers. They may cause some flexion and may push the terminal phalanx to one or other side. They are very frequently associated with osteo arthritis

elsewhere, and pathologically approximate in nature to osteo-arthritic nodules, but they may occasionally be seen in the victims of articular disease indistinguishable from rheumatoid arthritis or from chronic gout. Garrod states that the similar nodosities seen in gout differ in that they tend to be (1) limited to one or two digits, (2) *asymmetrical, and* (3) *more* bulbous and less nodular.

(*b*) *Morbus coxæ "senilis"* (Figs. 863 to 865) may occur in either sex at any age, but especially attacks males over 50. In other varieties of arthritis deformans, except spondylitis deformans, the female sex predominates.

There is generally a history of a severe trauma. The symptoms usually develop insidiously, but may arise so rapidly after injury as to lead to a faulty diagnosis of fracture of the femoral neck. The patient complains of a limp, and of pain and stiffness, worse after rest; *movement often elicits* a harsh, grating crepitus. The pain may be severe, and may be felt either in the groin or over the sciatic or anterior crural nerves. The gluteal and thigh muscles waste, and the knee-jerk is exaggerated on the affected side.



[illegible] the acetabular rim.

(*Dreadnought Hospital Museum, Greenwich*)

The head of the femur is rapidly worn down, the neck shortened, and the development of peripheral osteophytes, both on the femur and the acetabulum, is excessive. (Fig. 865.) The trochanter comes to lie above Nélaton's line; the limb is everted and somewhat adducted, and the hip eventually becomes immobile. It must be remembered that these exaggerated *changes only occur in neglected or improperly treated cases*; they should be prevented. Both hips may be involved, though usually in different degrees; if both are severely attacked and adducted, a "scissor-leg" deformity may ensue. Osteo-arthritic manifestations, such as Heberden's nodes, may be present elsewhere. Severe and prolonged sciatica is a frequent concomitant; it may often be diagnosed from true sciatica by the facts that the glutei, *instead of being unaffected,* become markedly wasted, and that the pain usually stops short of the knee. Radiography confirms the diagnosis

(*c*) In the *knees* osteo-arthritis is very common, especially in women near the menopause, but fortunately is rather more responsive to treatment than elsewhere. Pain is not marked, but stiffness after rest and in cold, damp weather is a prominent feature. Kneeling and rising from a seat become *increasingly difficult.*

The disease usually pursues a "dry" but may follow a "wet" course. In the former the only physical sign at first is a grating "scrunch," palpable and audible with or without the stethoscope, on slow movement, especially if the patella be pressed against the femur. Later, lipping of the edges of

all the constituent bones becomes obvious, the stiffness increases, and the knee tends to become slightly flexed and to adopt the valgus position, the patella becoming displaced outwards to rest on the external condyle. The leg and foot at the same time are somewhat everted.

In the "wet" type an early excess of synovial effusion fills the joint and the communicating bursæ; later the fluid dries up and the usual changes follow. In an intermediate type recurrent effusions alternate with "dry" periods, and are probably due to nipping of synovial fringes, villi, chondrophytes, or osteophytes.

(*d*) The metacarpo-phalangeal joint of the *thumb* is certainly one of the seats of election of osteo-arthritis (Garrod). It may even be attacked alone. The disease is also common in the corresponding joint of the hallux.

(*e*) The *temporo-maxillary joints*, although much more frequently affected in rheumatoid arthritis, may be attacked by osteo-arthritis, sometimes to a different degree on the two sides. The jaw becomes locked by dovetailing of osteophytes and, to some degree, by muscular spasm.

Prognosis.—The changes, once developed, are permanent, and the course of the disease tends to progression, but in some cases, especially in the early stages and in young victims, may be retarded or even arrested. The prognosis is perhaps best in the type that affects the knees in women about the menopause. Even in morbus coxæ "senilis," very good results accrue from attention to the first two principles of treatment mentioned below. The crippling is, on the whole, less extreme in osteo-arthritis than in rheumatoid arthritis.

Treatment.—Although *restitutio ad integrum* is not possible, something, occasionally much, may be done in most cases to alleviate symptoms and even to arrest progress.

The first two principles of surgical treatment, especially applicable to osteo-arthritis involving the lower limb, are—(1) Application of extension by means of Thomas's calliper walking splint and the abolition of harmful and painful pressures, and (2) gentle manipulation of the joint through its full range of movement daily. Although the radiographic appearances are not improved, the results are sometimes excellent from the point of view of the patient, who is chiefly concerned with the pain and disability rather than with the underlying pathological condition; even wasting may be partly repaired. The use of ordinary medical means of treatment, without attention to these more essential principles, is practically worthless; at the same time they must not be wholly neglected.

The general health must be conserved by a generous and varied diet and by attention to the excretion of effete products. In the belief that the increased body weight causes mechanical irritation in the knees, Llewellyn Jones recommends reduction of fat-forming foods, carbohydrates, fats, and alcohol, in women whose menopause is associated with osteo-arthritis of the knees and with rapidly increasing obesity. Care must be taken that the régime does not

interfere with the general health. Warm but not heavy clothing should be worn.

Cod-liver oil and malt, alone or with iron iodide, is often of use. Arsenic, guaiac, sulphur, tincture of iodine, syrupus ferri iodidi, sodium and potassium iodides, all have their uses. To relieve stiffness, guaiac, sulphur, and sodium iodide may be given together in cachets, and valerian may be added in cases associated with the menopause. Pain may be diminished by the administration of aspirin, with or without phenacetin and caffeine.

Locally, lin. pot. iod. cum sap., gently rubbed in, is of use. The wasted muscles should be regularly and gently massaged, except when the joint is irritable.

In osteo-arthritis, as distinct from rheumatoid arthritis, rest is of value, especially during the more painful and irritable stages; then it may even be advisable to apply weight-extension and to keep the joint at rest in good position. In some cases, especially in the "wet" type, strapping, even after the more irritable stages have ceased, is advisable; but it should then be removed at least once a day for massage, passive movements, and exercises. In all cases strains are to be avoided.

Hot-air and radiant-heat baths applied to the affected joints and followed by a tepid bath are of special value in osteo-arthritis; as a domestic though less efficient substitute, hot sand may be used. Warming through by means of diathermy is sometimes helpful; for this purpose both electrodes are broad and the current is smaller than that for "surgical" diathermy as used for the removal of tumours Spa treatment at Harrogate, Bath, Buxton, Strathpeffer, Baden, Wiesbaden, Aix-les-Bains, etc., may be very helpful. Bubbling *hot mineral springs often alleviate pain.*

Since the first edition of this System was published, a considerable amount of new work has been done on the surgical treatment of this disease, and surgery now holds out a greater prospect of help. As already mentioned, manipulation has definite value—for example, in osteo-arthritis of the hip; in the knee it must be applied with caution, for this joint is more liable to flare up into an exacerbation if roughly handled. In comparatively early cases improvement sometimes follows arthrotomy and lavage followed by immediate closure. In later stages in which stiffness, faulty position, and especially pain are prominent, surgical measures can again sometimes help. In disease of the hip, for example, in which usually the bad position is one combining flexion, adduction and rotation, good results have sometimes followed arthroplasty, with great after-care to prevent recurrence of the adducted position, in which such abnormal and painful strains are thrown upon the new joint. It must be admitted, however, that

arthroplasty sometimes fails, and many surgeons prefer to abolish movement of the hip altogether, and to rid the patient of his pain and faulty attitude by excising the head of the femur, jamming the divided neck firmly into the acetabulum, and aiming at ankylosis in good position, i.e. an abducted one. Although the hip is fixed, the patient often manages to walk with apparent mobility owing to the movements of the lumbar spine; moreover, the gait is now painless, and he therefore is greatly benefited.

Where it can be shown that, owing to their position, certain osteophytes are causing recurrent irritation of the joint or pressure neuralgia, it is justifiable to remove them by operation.

In some cases, for the relief of the pain caused by joint movement in morbus coxæ senilis, Albee induces ankylosis by operative measures, and R. Jones recommends an arthroplasty.

Buedinger and Rovsing have injected sterilized vaseline into the joint cavity; some reaction occurs, followed sometimes by alleviation of symptoms; it is not, however, a reliable method: the reaction may be unduly great, and the improvement is but temporary.

SPONDYLITIS DEFORMANS (ARTHRITIS DEFORMANS OF THE SPINE)

This disease is characterized by the predominance of [illegible] ossification. Its existence as a separate disease is a [illegible] similar spinal rigidity may be seen in gonorrhœal [illegible] rheumatoid arthritis, and in osteo-arthritis, and [illegible]

[illegible]

we must use the term somewhat loosely to [illegible] spinal ossification predominates. Rather [illegible] general rheumatoid arthritis or osteo-arthritic [illegible] There remains a series of cases with [illegible] classified thus:—

1. The osteo-arthritic variety, in [illegible] osteophytes and the [illegible] condensation.
2. The variety in which [illegible] vails, and in which [illegible] and atrophy (Leri).

[illegible]

become ossified. [illegible] definite osteophytes. [illegible] materially diminished. [illegible] escape change. [illegible]

Strumpell-Marie type (*spondylose rhizomélique*), which affects the spine and the root-joints (hip and shoulder), and commonly begins in the lumbar region. No associated neural lesions have been described. (*b*) *Von Bechterew's type* (*la kyphose hérédo-traumatique* of French writers) chiefly attacks the cervical and upper dorsal regions, and has been found to be associated with localized meningitis. The meninges were adherent to the posterior root ganglia, and degeneration had spread along the nerve-roots into the posterior spinal columns; there was also slight degeneration of anterior roots. It has been stated that the anterior common ligaments are more affected in this than in the Strumpell-Marie type.

Etiology.—The predisposing causes are those of arthritis deformans generally. In some cases senility combined with mechanical stress caused by faulty position has been held responsible. The von Bechterew type, especially, has been ascribed to a neurotrophic cause, the associated meningeal and neural lesions being considered to be primary. Other writers have blamed a combination of heredity and injury.

Gonorrhœa, syphilis, rheumatism, tuberculosis, typhoid, and pneumococcic and staphylococcic infections have also been regarded as the primary causes.

Clinical features.—The von Bechterew type has, with a few exceptions, been recorded only in males; the Strumpell-Marie and the osteo-arthritic types are found in both sexes, but most often in males. The onset, although occasionally rapid, is usually slow and insidious

Sensory symptoms are generally first noticed, often in the form of neuralgic paroxysms in the head, neck, arms, or intercostal spaces; in the Strumpell-Marie type the pains may radiate from the lumbar region. Paræsthesiæ and sometimes areas of hyperalgesia are found. Later there may be patches of analgesia. The radiating pains are usually unilateral, but may become bilateral. The sensory symptoms are such as might be explained by pressure on the nerves at their foramina of exit; but in autopsies no encroachment on the foramina has been found, except occasionally in the purely osteo-arthritic type.

Gowers has recorded sympathetic lesions as evidenced by pupillary changes.

In the *muscular* system early spasm is frequent; later there is some slight wasting and weakness, especially in the scapular and spinal muscles, but the atrophy is not by any means so well marked as in the case of generalized rheumatoid arthritis. In the osteo-arthritic form of spondylitis there may be definite pressure on nerve-roots, resulting in corresponding paralyses.

Rigidity is perhaps the most marked phenomenon, and gradually increases. It may affect the whole spine or be restricted to one part; movement may be limited more in one direction than in others.

Deformity.—The spine usually becomes rigid in a kyphotic position, but, in the osteo-arthritic form especially, it may be straightened and poker-like. Rarely, rigidity occurs without deformity. The kyphosis may affect the whole spine or may be obvious only in the neck and thorax; in the latter case the lumbar spine shows no compensatory lordosis. There may be some wide lateral curvature and cervical rotation, especially in the osteo-arthritic variety. The chest becomes flattened antero-posteriorly and fixed, so that respiration is almost wholly abdominal.

In the Strumpell-Marie type the hips are rigid and the thighs somewhat flexed, adducted, and externally rotated; occasionally, however, extension

replaces flexion. The shoulders may also be stiff. In von Bechterew's type the limbs are unaffected and the kyphosis is located in the cervico-dorsal region; there is no compensatory lordosis. In all varieties the head is projected forwards and the face averted so that the chin may even be in contact with the chest; to look forwards the patient is driven to the expedient of flexing his knees in order to bring the upper spine farther backwards. Occasionally the knees also are slightly affected.

The radiographic appearances are of the greatest value in diagnosis.

Treatment consists in relieving pain, in supporting the spine and especially the head, in massage, and in the administration of iron and arsenic. The disease is, however, progressive; therefore every care should be taken by means of light supporting jackets to prevent the extreme deformity during the period in which it is still developing.

NEUROPATHIC ARTHROPATHIES

These arthropathies will be considered under the following headings:—

1. Hysterical joints.
2. Tabetic arthropathy.
3. Syringomyelic arthropathy.
4. Arthropathies associated with other spinal, with cerebral, or with peripheral nervous lesions.

The term Charcot's joint is often used as synonymous with tabetic arthropathy, but, inasmuch as that writer described the syringomyelic and other organically neuropathic arthropathies, these also should be included under that title.

1. "HYSTERICAL" JOINTS (ARTICULAR NEUROMIMESIS)

This form of arthropathy is characterized by hyperalgesia and muscular contractures without any organic joint lesion. It is especially important *in that it chiefly attacks young people and may interfere with their future* career, and that its treatment is essentially different from that of true

steria," and may be the only
with some other personal or

Although it is stated that most cases occur in young women and girls, males are by no means exempt. The age-incidence is usually at or soon after adolescence, but the disease may appear in young children, or, as in one of Charcot's cases, as late as 45. The onset is not infrequently determined by a localized trauma, or by a physical or an emotional shock; railway accidents have especially been blamed, and the condition was not very uncommon during the War, a desire for compensation, either material or sympathetic, is sometimes a factor.

The arthropathy may commence during an hysterical attack, or may result from suggestion, or from imitation of another child with a real organic *articular lesion*; in some cases no cause can be discovered.

The joint most frequently affected is the hip, but the knee, ankle, shoulder, or more rarely the hand, may be at fault. Usually the condition is limited to one joint, but it has been observed in many articulations of the same side, and in symmetrically bilateral joints.

Clinical features.—The patient may or may not show other signs of hysteria, such as anæsthetic patches, hysterogenetic zones, or limitation of the visual fields.

The onset is generally sudden and the symptoms are at once complete. If trauma be an etiological factor, the arthropathy may follow immediately, or may ensue after two or three days of "*méditation psychique.*"

The characteristic symptoms are exaggerated pain, disproportionate hyperalgesia, stiffness (often in abnormal postures), and usually other hysterical stigmata, without articular lesions and generally without swelling or muscular atrophy.

The *pain* and *tenderness* are described in a vivid manner with great wealth of detail and much protestation against palpation or even against stroking They are quite disproportionate to the other signs of disease, and are often diffuse, and not confined to the area of the joint. The pain disappears at night; the patient has nothing like the starting-pains of tuberculous disease, and may be observed to move with comparative freedom in bed. An important feature of the hyperalgesia is its superficial localization; the patient submits with difficulty to the slightest touch, but often bears deeper pressure with equanimity, especially if her attention be distracted. Sometimes even in the hyperalgesic area patches of insensibility to pin-prick may be found. In an early case, in which the patient has not yet been subjected to suggestion by frequent questionings and pointed examinations, the cutaneous sensory stigmata are often absent.

In some cases hysterogenetic points may be found; a touch there may precipitate an hysterical crisis. There may be considerable variation from the usual type of sensory disturbance described above. Sometimes cutaneous hyperalgesia is absent, or deep-seated pain on pressure is elicited with or without superficial hyperæsthesia. Occasionally percussion at a distance may cause pain in the region of the affected joint.

Rigidity.—(*a*) The typical stiffness is due to strong muscular contractures, which form one of the most constant signs. Like the hyperalgesia, it is often very exaggerated, and may not be confined to the muscles that play over the affected joint. Any attempt to overcome the contracture is strongly resisted and induces complaints of severe pain; but if the patient's attention be distracted the joint may frequently be moved to some degree, only to be immediately stiffened again when she notices the examiner's manœuvres.

In an early case the rigidity may relax during sleep; in a severe one, however, it may persist.

The fact that under deep general anæsthesia the contracture gives way is an important diagnostic sign. Sometimes during recovery from anæsthesia the patient still permits free passive movement of the limb, until, noticing [illegible]

[illegible] us shorten- [illegible] sists under chloroform and may require [illegible].

The *posture* is frequently diagnostic, for it is often forced and extreme, bu[illegible] (See p. 953.) Perhaps the commonest pos[illegible]ersion with some flexion, which ma[illegible] *sometimes to the fullest extent*; in [illegible] the foot may assume an equino-

[1] Charcot, *Bull. Méd.*, 1887; Blocq, *Nouv. Iconog. de la Salpêtrière*, 1889. Terrillon, *ibid.*

varus attitude, and the fingers may be strongly flexed or adopt a bizarre mixture of positions.

The posture is apt to vary greatly and may not be constant; it may change without regularity or apparent reason.

Functional loss of power is almost always marked. If the patient will walk at all, she limps in an exaggerated and unusual manner, not at all like the gait of genuine hip disease.

Muscular atrophy is generally strikingly non-existent in spite of the prolonged disuse. Exceptionally it is present to a slight degree, but is diffuse and not localized to definite groups of muscles such as the extensors (Charcot).

The *absence of swelling and of local heat* are valuable diagnostic signs. The part is usually colder than the other side, and is often blue. Exceptionally, however, diffuse transient periarticular œdema may be present, with or without some local heat. Transitory local warmth and flushing may also be seen, especially during active attempts to use the joint. Occasionally irritant attempts at treatment may cause both warmth and swelling.

Under general anæsthesia the muscular contractures and faulty attitudes disappear and the joint can be moved well and appear normal. During awakening the cutaneous hyperalgesia reappears, soon followed by rigidity.

Course and prognosis.—After a suddenly complete appearance the symptoms may remain for months or years without change, and the faulty attitude eventually persists even at night.

Cure may be as dramatic as the onset, and may follow a fall, a sudden physical or mental shock, or religious or emotional stress. In some cases the contractures gradually disappear, but relapses are to be feared as long as hyperalgesia remains. The general health is good.

Di[illegible] [illegible] cteristics already [illegible] by the youth of [illegible] ment such as by prolonged fixation or by irritant applications.

There remains a very important and difficult class of mixed cases in which early tuberculous or other organic disease may be masked by superimposed hysteria. These cases demand great caution, for failure to observe the underlying organic lesion may lead to wrong treatment with disastrous results. Careful radiography and examination under chloroform are necessary to determine the absence of associated organic disease. The fallacies of the latter method are, on the one hand, a possible failure to reveal an early tuberculous change, and, on the other hand, the possibility that in old-standing neuromimesis there may be articular creakings and fibro-tendinous bands

Treatment. (*a*) General.—The diet should be nourishing and full, an embargo being laid on the non-nutritious but appetite-destroying foodstuffs in which many of these patients indulge.

Definite rest periods, combined with gentle exercise short of fatigue, should be ordered, and the general habits of the patient regulated and defined. In some cases a "rest cure," isolation from friends and overfeeding, as recommended by Weir-Mitchell, is of value; especially if followed later by a "work cure" in which the patient is interested in easy mechanical work. Iron, arsenic, strychnine, and valerian are of subsidiary but undoubted value. Constipation must be overcome and abnormal intestinal

Clinical features.—*The patient may or may not show other signs of hysteria, such as anæsthetic patches, hysterogenetic zones, or limitation of the visual fields.*

The onset is generally sudden and the symptoms are at once complete. If trauma be an etiological factor, the arthropathy may follow immediately, or may ensue after two or three days of "*méditation psychique*."

The characteristic symptoms are exaggerated pain, disproportionate hyperalgesia, stiffness (often in abnormal postures), and usually other hysterical stigmata, without articular lesions and generally without swelling or muscular atrophy.

The *pain* and *tenderness* are described in a vivid manner with great wealth of detail and much protestation against palpation or even against stroking. They are quite disproportionate to the other signs of disease, and are often diffuse, and not confined to the area of the joint. The pain disappears at night; the patient has nothing like the starting-pains of tuberculous disease, and may be observed to move with comparative freedom in bed. An important feature of the hyperalgesia is its superficial localization; the patient submits with difficulty to the slightest touch, but often bears deeper pressure with equanimity, especially if her attention be distracted Sometimes even in the hyperalgesic area patches of insensibility to pin-prick may be found. In an early case, in which the patient has not yet been subjected to suggestion by frequent questionings and *pointed examinations, the cutaneous sensory stigmata are often absent.*

In some cases hysterogenetic points may be found; a touch there may precipitate an hysterical crisis. There may be considerable variation from the usual type of sensory disturbance described above. Sometimes cutaneous hyperalgesia is absent, or deep-seated pain on pressure is elicited with or without superficial hyperæsthesia. Occasionally percussion at a distance may cause pain in the region of the affected joint.

Rigidity.—(*a*) The typical stiffness is due to strong muscular contractures, which form one of the most constant signs. Like the hyperalgesia, it is often very exaggerated, and may not be confined to the muscles that play over the affected joint. Any attempt to overcome the contracture is strongly resisted and induces complaints of severe pain; but if the patient's attention be distracted the joint may frequently be moved to some degree, only to be immediately stiffened again when she notices the examiner's manœuvres.

In an early case the rigidity may relax during sleep; in a severe one, however, it may persist.

The fact that under deep general anæsthesia the contracture gives way is an important diagnostic sign. Sometimes during recovery from anæsthesia the patient still permits free passive movement of the limb, until, noticing the surgeon's manœuvres, she suddenly stiffens the muscles again.

(*b*) As a very rare sequel in long-continued cases, true tendinous shortening and peritendinous bands [1] may give rise to a stiffness that persists under chloroform and may require careful tenotomy.

The *posture* is frequently diagnostic, for it is often forced and extreme, but not that of the greatest ease. (*See* p. 953) Perhaps the commonest positions are—in the hip, adduction, inversion with some flexion, which may be extreme; in the knee, flexion, sometimes to the fullest extent; in the shoulder, strong adduction; whilst the foot may assume an equino-

[1] Charcot, *Bull. Méd.*, 1887; Blocq, *Nouv. Iconog. de la Salpêtrière*, 1889. Terrillon, *ibid.*

varus attitude, and the fingers may be strongly flexed or adopt a bizarre mixture of positions.

The posture is apt to vary greatly and may not be constant; it may change without regularity or apparent reason.

Functional loss of power is almost always marked. If the patient will walk at all, she limps in an exaggerated and unusual manner, not at all [illegible] the pro- [illegible] is diffuse [illegible] extensors (Charcot).

The *absence of swelling and of local heat* are valuable diagnostic signs. The part is usually colder than the other side, and is often blue. Exceptionally, however, diffuse transient periarticular œdema may be present, with or without some local heat. Transitory local warmth and flushing may also be seen, especially during active attempts to use the joint. Occasionally irritant attempts at treatment may cause both warmth and swelling.

Under general anæsthesia the muscular contractures and faulty attitudes disappear and the joint can be moved well and appear normal. During awakening the cutaneous hyperalgesia reappears, soon followed by rigidity.

Course and prognosis.—After a suddenly complete appearance the symptoms may remain for months or years without change, and the faulty attitude eventually persists even at night.

Cure may be as dramatic as the onset, and may follow a fall, a sudden physical or mental shock, or religious or emotional stress. In some cases the contractures gradually disappear, but relapses are to be feared as long as hyperalgesia remains. The general health is good.

[illegible] cteristics already [illegible] by the youth of some patients, and by the results of faulty previous treatment such as by prolonged fixation or by irritant applications.

There remains a very important and difficult class of mixed cases in which early tuberculous or other organic disease may be masked by superimposed hysteria. These cases demand great caution, for failure to observe the underlying organic lesion may lead to wrong treatment with disastrous results. Careful radiography and examination under chloroform are necessary to determine the absence of associated organic disease. The fallacies of the latter method are, on the one hand, a possible failure to reveal an early tuberculous change, and, on the other hand, the possibility that in old-standing neuromimesis there may be articular creakings and fibro-tendinous bands.

Treatment. (*a*) **General.**—The diet should be nourishing and full, an embargo being laid on the non-nutritious but appetite-destroying food-stuffs in which many of these patients indulge.

Definite rest periods, combined with gentle exercise short of fatigue, should be ordered, and the general habits of the patient regulated and defined. In some cases a "rest cure," isolation from friends and overfeeding, as recommended by Weir-Mitchell, is of value; especially if followed later by a "work cure" in which the patient is interested in easy mechanical work. Iron, arsenic, strychnine, and valerian are of subsidiary but undoubted value. Constipation must be overcome and abnormal intestinal

fermentation, if present, relieved by the administration of paraffin, phenol, β-naphthol, salol, or mild mercurial laxatives such as hydrarg. c. cretâ.

(*b*) **Psycho-therapeutic.**—Everything must be done to divert the patient's attention and strongly to reassure her. The surgeon should make use of every necessary diagnostic or therapeutic manœuvre, such as the administration of chloroform, as a peg on which to hang a curative suggestion. Treatment by suggestion in the semi-hypnotic state is often of use, but complete hypnosis should be used with caution. In a few cases intimidation may prove of value, but must only be cautiously used by a tactful surgeon in whom the patient reposes entire confidence.

Religious suggestions, such as those adopted, perhaps in excess, by Christian Scientists, and those implied by a pilgrimage, may sometimes succeed where more ordinary methods fail.

Wilms and Lohrer have used spinal analgesia with good effect; and sometimes a simulated surgical operation with a superficial incision is followed by cure. No one method promises certain success; great ingenuity and persistence are often required.

(*c*) **Local.**—All energetic treatment which will strongly direct the patient's attention to the joint is inadvisable. Therefore blisters, cauterization, iodine paint, fixative plasters or apparatus, and forcible manipulation should be avoided. The joint should be kept warm, for it is often cold. [illegible] ontracted helps to [illegible] e converted into [illegible] if combined with [illegible] ng has occurred, tenotomy and manipulation are necessary; these should be done with care to prevent the undue separation of the ends of the divided tendons.

2. *CHARCOT'S JOINTS*

The condition thus named may be associated with tabes dorsalis, with syringomyelia, or more rarely with myelitis, cerebral lesions, or peripheral neuritis. Of the method of production we are ignorant; normally, impulses from the joints probably travel by sensory nerves to some special centre or centres, and are thence returned through the vaso-motor nerves in the form of "trophic" influences. The joint in this way acts as a trophic station for its neighbourhood, and any interruption of the trophic arc leads to articular disturbance.

Charcot's joints due to spinal disease are common; those of cerebral and peripheral origin are rare.

Tabetic Arthropathy

Although only about 3 per cent. of tabetic patients ever develop an arthropathy, while about 30 per cent. of the victims of syringomyelia suffer articular lesions, yet, owing to the greater rarity of the latter disease, tabetic arthropathy is the common form of Charcot's joint.

Pathology.—The nervous system shows the usual signs of tabes dorsalis. The articular lesions may be divided into four



Fig 1 —Charcot's ankle, hypertrophic type

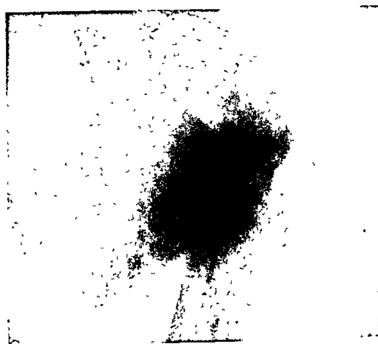


Fig 2 —Charcot's knee, hypertrophic type; same case as Fig. 1.

PLATE 142.

groups—the atrophic, the hypertrophic, the osteo-arthritic, and the hydrarthrotic. Hydrarthrosis rarely, if ever, stands alone, but is associated with other changes, most commonly with atrophy. Therefore three types of the disease may be described, viz. (a) the hypertrophic, (b) the atrophic, (c) the osteo-arthritic. These three types are often mixed in the same joint.

The morbid anatomy of the *osteo arthritic type* (c) cannot be differentiated from osteo-arthritis, except by the associated spinal lesions, and therefore requires no further description.

The *atrophic type* (b) has a predilection for the shoulder and hip, and frequently shows a considerable and even, especially on the shoulder, very excessive hydrarthrosis. It is characterized by absorption of the osseous extremities, which may very rapidly proceed to such an extent that the shafts may end in points projecting into a large, distended capsular sac. Occasionally these points have perforated the soft tissues to some extent. The range of joint movement is increased, often to a bizarre degree, and dislocations frequently occur.

The atrophy primarily appears in the bones, and may even cause disappearance of some of the carpal and other small bones. The affected bone-ends become rubbed and often eburnated, the articular surfaces are deformed, and small pieces may be separated. Definite fractures into joints are not very uncommon. The cartilage, at first comparatively immune, soon becomes destroyed.

The capsule may be enormously distended, and in extreme cases may leak. Occasionally calcareous and bony plates and knobs may be attached to it, though this is more common in the hypertrophic form. Intra-articular ligaments and tendons are often destroyed, and capsular and extra-articular ligaments are stretched; the capsule may be inextricably blended in a fibrous mass with surrounding structures. The synovial membrane is thickened and may show fringes and sessile or pedunculated fibro-cartilaginous nodules. In the late stages it may be destroyed. The effusion varies greatly in amount; it may be excessive, especially at first, but tends to decrease later; or it may be slight from the beginning. The latter statement is more true of the hypertrophic variety. It is rather viscid and slightly yellow; sometimes it is hæmorrhagic; it is never purulent unless secondarily infected from a neighbouring perforating ulcer or other septic focus.

The *hypertrophic type* (a) is especially well seen in the knees. (Plate 142.) The non-osseous lesions are similar to those described, but calcareous and osseous plaques and knobs formed in and on the capsule are much more prominent and may be very large.

The bone-ends show, in association with atrophy in places, a considerable peripheral hypertrophy that is lumpy and massive rather

than nodular as in osteo-arthritis. Fracture of some of these lumps may occur; similarly, fractures of condyles are not very uncommon: reunion does not usually follow. The great hypertrophic masses are often more marked on one side of the joint than on the other; very considerable deformity and perhaps luxation result. If there be associated hydrarthrosis the joint may feel like a bag full of loose bones.

The joints affected.—The knee is involved in nearly half the cases, the hip in about one-fifth; the foot and ankle, the shoulder, the wrist, the elbow, follow in that order of frequency. The vertebral articulations may in rare cases be attacked.

It is not uncommon to find two joints affected in one patient, *e.g.* the knee and hip, both knees, the knee and shoulder, etc.

Complications.—(1) When hydrarthrosis is present the communicating bursæ may be filled up; but in addition serous effusions have been noted in neighbouring separate bursæ such as the prepatellar.

(2) Rarely—perhaps after some trauma—hæmarthrosis may occur in the joint.

(3) There may be a general hard œdema, either of the whole limb or of the tissues adjacent to the diseased joint. This may be a trophic œdema, but Debove has suggested that it is due to leakage from an over-distended joint.

(4) Perforating ulcer of the foot may be present and may form a septic focus from which infection of the joint may occur. This event is relatively more frequent in arthropathy due to syringomyelia. Such an ulcer may result from slight neglected trauma to the insensitive part, or may originate as a sinus leading to carious bone. It is most common near the ball of the great toe or on the pad of the foot. It is extremely intractable.

(5) Suppuration of the joint may follow secondary infection.

(6) Dislocation may occur in either the atrophic or the hypertrophic form.

Clinical features.—The clinical appearances of the affected joint are those naturally associated with the morbid changes noted above. The onset of symptoms is nearly always sudden, dramatic, and painless. Sometimes the patient wakes from sleep to find that a joint has become greatly swollen, flail-like and useless; or sometimes the changes follow a slight twist or sprain, as in walking or swimming; the determination of a tabetic arthropathy by a trivial injury received at work may raise questions of medico-legal interest. Occasionally, however, the symptoms may appear insidiously and progressively. In any case, although the onset seems so sudden, probably the changes have been in preparation for some time, accompanied by slight premonitory symptoms ignored by the patient. The appearance of a Charcot's joint is generally an early manifesta-

tion, and may be the first evidence, of the existence of tabes—the other signs, such as the Argyll-Robertson pupil, loss of knee-jerks, visceral crises, ataxia, Romberg's sign, strabismus, dysuria, and the sensation of walking on felt, following later. Frequently, however, careful inquiry will establish the previous existence of lightning pains, and examination may reveal the presence of the Argyll-Robertson pupil and of anæsthetic patches on the nose and elsewhere.

Around the joint there is often a firm œdema, which may extend



Fig. 866.—Tabetic osteo-arthropathy.



Fig. 867.—Same case as Fig. 866 with splint applied.

(*By courtesy of Dr. F. M. R. Walshe*)

for some distance down the limb. A crepitus may be felt. Hydrarthrosis may be so extreme as to cause dilatation of superficial veins.

Movements may be painlessly permitted through an abnormally wide range; thus, in the knee, lateral flexion and hyperextension may be possible. (Figs 866, 867, 868, 869.)

Occasionally temporary improvements may occur, but recurrence is probable.

In the hypertrophic form there may be considerable effusion, but

the most obvious characteristic is the presence of great bony and calcareous bosses on the osseous extremities, and perhaps in the capsule and in other periarticular structures. In this type abnormal mobility is not so marked, though the movements are often modified into abnormal directions and the joint is much deformed. The movements are sometimes accompanied by loud crackling noises.

The **prognosis** varies greatly in different cases. In some, after several weeks, the swelling may gradually disappear and the normal



Fig. 868.—Same case as in Figs. 866, 867.



Fig. 869.—*Cf.* with Fig. 866 to show the unnatural mobility at the knee.

be apparently regained; this improvement may be permanent or only temporary. In others the joint changes may become stationary, without either regression or progression; but in the graver forms the loss of function and the distortion steadily increase.

Diagnosis is usually readily made by the discovery of some other tabetic manifestations, by the painless sudden onset, by the clinical and radiographic characters of the swelling.

Treatment can only be palliative, and most usually consists in the use of an orthopædic apparatus to secure the joint and

prevent abnormal movements. The instrument must be carefully applied and the greatest watchfulness maintained to prevent pressure or rubbing; otherwise ulceration and infection very readily supervene.

In cases of extreme hydrarthrosis aspiration under the most rigidly aseptic precautions is sometimes justifiable.

Arthrotomy and lavage is useless and dangerous.

Although a few good functional results have been claimed for excision, disaster more often occurs owing to the difficulty of the operation, the imminent danger of infection in the trophically disorganized tissues, and the frequent failure of ankylosis (Ullmann).

Similarly, resort should only be had to amputation in exceptional cases.

3. SYRINGOMYELIC ARTHROPATHY

Articular lesions occur in from 25 to 30 per cent. of cases of syringomyelia, and are therefore frequent enough to rank amongst its cardinal symptom [illegible] cular atrophy, especiall [illegible] out also often involvin [illegible] the shoulder girdle; [illegible] hange in the muscular [illegible] of whitlows, perforating ulcers, and bullous eruptions; and (*d*) scoliosis, which is present in a proportion of cases variously stated by different authors as between 20 and 70 per cent.

The underlying morbid change is a gliomatous degeneration compressing and destroying the spinal grey matter in the neighbourhood of the central canal, especially posteriorly. It may occur extensively through the spine, or in rare cases be confined to the lumbar region, but nearly always is situated in the cervico-dorsal area.

The *articular lesions*, therefore, are very much more frequent in the upper than in the lower limbs, thus differing from those seen in tabes. They are especially common in the shoulder and elbow.[1]

They are similar to those seen in tabes, and may be grouped under the atrophic, the hypertrophic, and the hydrarthrotic types, the last being most frequently associated with the atrophic variety. Atrophy predominates in the shoulder, but the other joints all tend to hypertrophic changes; in the elbow there may be a mixture, but hypertrophy is usually the more prominent.

Ankylosis of the affected joint has been observed, but is very rare.

Dislocations and fractures are frequent complications; in the shoulder especially luxations are very common and may even be one of the first-observed signs of the disease. Owing to the frequent association with trophic ulcers and whitlows, infections of the joints are relatively very common; the suppuration is fortunately often of a low grade of virulence, but in some cases it leads to the death of the patient.

[1] [illegible]

Hip	6	Acromio-clavicular	1

The **clinical features** are very similar to those of tabetic arthropathy, but of course the non-articular phenomena of syringomyelia *replace* those of locomotor ataxia. The onset is often sudden, but it is gradual in a greater proportion of cases than is the rule in tabes. Periarticular *swelling* and hard œdema may be present, and dislocations and fractures are common; trophic sores, osseous necrosis, and articular *suppuration* are more frequent than in tabes.

The patient is usually aged about 40, but may be as young as 20. Owing to the greater liability of men to syringomyelia and to traumata, two-thirds of the arthropathies occur in the male sex (Schlesinger).

Although the condition may become spontaneously cured, it usually either remains stationary for a considerable time or, more frequently, becomes complicated by infection, fracture, or dislocation

Treatment.—Attempts at surgical intervention, even by aspiration, are dangerous and unsatisfactory, owing to the risk of pyogenetic infection. Complications such as dislocation, fracture, or infection call for the appropriate treatment, and occasionally amputation of an infected part is necessary to save life.

Removal of necrotic bone from sinuses is sometimes necessary, and may often be done painlessly owing to the analgesic condition of the part.

4. ARTHROPATHIES ASSOCIATED WITH OTHER SPINAL, WITH CEREBRAL, OR WITH PERIPHERAL NERVOUS LESIONS

These arthropathies are rare, but may occur in paralysis due to any nervous cause. The purely hydrarthrotic form is much commoner than the true arthropathy; it consists of an indolent effusion, occasionally though rarely hæmorrhagic, which may fill one or more joints of the paralysed part. It may be associated with palsy, due to fractured spine, Pott's disease, myelitis, peripheral neuritis, or anterior poliomyelitis. I have observed it in one case of cerebral hemiplegia.

The cases of true hypertrophic or atrophic arthropathy are much more rare, but have been recorded as following fracture of the spine. Mme. Déjerine and Ceillier have described (1919) a number of cases of paraplegia [illegible]

the name *para-osteal arthropathy.*

PENETRATING WOUNDS OF JOINTS—SPRAINS

PENETRATING WOUNDS

Such wounds involve grave risk of suppurative arthritis with its terrible sequelæ. As a rule, some greasy glairy synovial fluid exudes; but if the aperture into the joint is small or valve-like no such escape occurs, and the surgeon may doubt whether the joint has actually been opened.

The injury is followed by reaction and intra-articular effusion; this soon settles down if infection have not occurred, but if pyogenetic

micro-organisms have secured an entrance and develop, acute suppurative arthritis ensues.

Treatment.—In all cases rest with the limb elevated is essential. *When the surgeon doubts actual penetration* of the joint, he must avoid all probings or other manœuvres likely to carry organisms into the articular cavity; he must be content, after thorough cleansing of the superficial wound and its surroundings, to cover it with antiseptic dressings, to secure rest, to apply elastic pressure, and to await the issue. If a rising leucocyte count, the development of fever and of pain, heat, tenderness, of limitation of movement and of effusion into the joint indicate suppuration, he should open the joint and treat the case as one of suppurative arthritis (*see* p. 886). If he is in doubt whether suppuration is occurring, it is legitimate to ascertain the nature of the articular contents by aspiration through thoroughly purified skin at a distance from the original wound. If the fluid withdrawn is turbid but not purulent, the joint should be washed out through two cannulæ, the exit one being the larger, and the further progress anxiously watched.

If penetration have undoubtedly occurred, but the wound be small and infection doubtful, the safest plan is to cleanse and dress the superficial wound and its surroundings, and to await events, observing the patient's general condition and the local phenomena very closely. The appearance of signs of infection calls for arthrotomy, and treatment as for acute infective arthritis (p. 886).

When the wound is large or infection is certain or probable, the edges of the wound should be freely excised and the joint thoroughly washed out with flavine (1 : 3,000), or with biniodide of mercury (1 : 5,000), followed by flushing with normal saline solution; then the opening in the synovial membrane should be sutured with catgut, the more superficial part of the wound dressed with a flavine pack, and a "delayed primary suture" made after twenty-four hours. The knee must be vigilantly watched for any signs of progressive inflammation, which will demand reopening and drainage.

If suppuration occur, all the treatment for suppurative arthritis must be adopted, including drainage, lavage, baths, and attention to the general health.

SPRAINS

A sprain results from the direct or indirect application of a sudden strain to the joint. As a result, hæmorrhagic extravasation occurs into the periarticular tissues, and sometimes into the articular cavity itself. The synovial membrane suffers either a number of small lacerations or a gross tear. The ligaments are either torn or partly separated from their bony attachments or undergo separation of their fibres Profuse synovial effusion is the rule.

Clinical features.—Severe sickening pain accompanies the accident, and continues for some hours or days, especially when the joint is moved. The part is useless, rapidly swells, and shows bruising. Tenderness is often acute over the torn ligament. As a rule the condition clears up under treatment. Its course may, however, be complicated by the simultaneous fracture of adjacent bones Moreover, if the patient have pyogenetic organisms travelling in his blood from some focus elsewhere, he may develop an acute suppurative arthritis in the damaged articulation.

If the effusion be very great and persistent the ligaments may lose tone and the part remain subject to recurrences of suffusion. In other cases, where considerable injury has been done to the ligaments or to articular cartilages, adhesions, extra-articular or intra-articular, may result.

Neglect of a sprain in a person predisposed to tuberculosis is a prominent factor in the etiology of tuberculous arthritis; this sequel is especially liable to occur after sprains insufficiently severe to compel proper rest and treatment. Osteo-arthritis, too, may follow a sprain, especially in the middle-aged and elderly.

Treatment.—The limb should be bandaged with crêpe or other elastic material, and kept at rest in an elevated position between sand-bags until all pain and tenderness have disappeared. Evaporating lotions, such as lot. plumbi, are soothing, and aid the elastic pressure and rest in preventing excessive effusion. Gentle massage of an effleurage type may be initiated at once; it relieves pain and hastens the absorption of exudates. When pain is inconspicuous, massage of a deeper type and passive movements should be begun. Active movements against gradually increasing resistance should be adopted as soon as the acute stages have passed; they are of greater value in preventing stiffness and restoring function than are passive movements alone.

No weight-bearing should be permitted until the pain, tenderness, and effusion have disappeared. When the affected joint is the ankle, care should be taken for a month or two to prevent strains to the recently healed and still weak ligament, usually the external lateral one; this may be done by thickening the sole and heel of the boot, about ½ in., on the outer side.

If the effusion shows a disposition to persist, hot and cold douches, combined with elastic pressure, or, later, the application of a Scott's dressing, are of value.

DISLOCATIONS

A dislocation (luxation), or displacement of the distal constituent bone of a joint into an abnormal position in relation to its proximal fellow, may be traumatic, pathological, or congenital in origin. A *traumatic* disloca-

tion is a sudden displacement of a bone in a healthy joint by violence, or by strong muscular action to a degree unexpected and unprepared for by the opposing muscles. A *pathological* dislocation results from a slight and negligible trauma in a joint of which the articular surfaces, retentive ligaments, or supporting muscles have been altered or weakened by disease, as in Charcot's arthropathy and in tuberculosis. *Congenital* dislocations occur before birth; some of them are probably due to faulty intra-uterine position; others are rather misplacements than displacements, and are due to imperfect development.

Dislocations may be *compound* if associated with an open wound into the joint; *complicated* if combined with fracture or with injury of important nerves or vessels.

In a *complete* dislocation the corresponding articular surfaces quite lose their normal relations to one another, in an *incomplete* dislocation or subluxation the separation is only partial, and the articular surfaces have suffered a change rather than a loss of relation to one another.

1. TRAUMATIC DISLOCATIONS

Etiology.—The essential cause is a strain, due to external violence or to excessive muscular action, sudden and great enough to damage the ligaments and separate the bones. The violence is usually indirect, and is applied in such a manner as to lever the head of the bone through a tear in the capsule of the joint. Dislocation by direct violence sufficient to drive one bone away from its fellow is rare, and is most often complicated by fracture. In some loose joints, which depend more for their integrity upon muscular and ligamentous than upon bony strength, such as the shoulder or the temporo-maxillary joint, sudden, strong muscular effort, such as that involved in throwing a cricket-ball or in yawning, may produce dislocation; this accident is more liable to occur if the ligaments are weakened and stretched as the result of previous dislocations or of diseases.

The age of the patient is an important factor. Dislocations are rare in childhood and youth, but are much commoner at or soon after middle age. Men are more often subjected to injury and are therefore more liable to dislocations than are women. Anatomical features also play an important part: the shoulder, since it relies for its strength chiefly upon the muscular and ligamentous structures, is much more likely to be dislocated than the hip, in which there is a strong bony interlocking.

Mort[illegible] other ligaments are torn in a degree [illegible] with the original violence. After a [illegible] firmly, but it may remain open in a few cases; although the stretched ligaments usually in time almost return to the normal, they not infrequently remain permanently weak and predispose the joint to further dislocations. The articular bony surfaces may be fractured, though sometimes only to the minor extent of suffering displacement of fragments to which ligaments are attached. The articular or intra-articular cartilages may be torn or be separated from their attachments. There is alw[illegible]

Injuries to nerves, compl[illegible] are not very uncommon. T[illegible] or may attend efforts at r[illegible] and sciatic nerves are the most frequent victims (see pp. 412, 417, 428). Gross injuries to vessels are fortunately rare. The axillary vessels may be torn in dislocation of the shoulder, or they may be so bruised and stretched that

they rupture during the process of *reduction*; *this danger is especially great* in the manipulation of an old-standing dislocation.

Sequelæ.—(1) The joint usually recovers *almost full usefulness*, although for a time some stiffness and perhaps slight aching pain in bad weather are noticeable.

(2) In some cases, *especially if massage and passive movements* have not been adopted early, this stiffness may be so great as to affect very materially the usefulness of the limb.

(3) An associated fracture may heal with sufficient callus-formation to interfere mechanically with the *joint movement*.

(4) A form of monarticular osteo-arthritis is liable to occur and to cause much disability and discomfort; therefore to elderly patients, especially those with marked articular crepitations or other evidence of chronic arthritic changes elsewhere, a guarded prognosis should be given.

(5) The dislocation may become habitually recurrent, the lesion *reproducing itself on the slightest pretext. The factors that seem to* come into play are undue laxity of the ligaments and muscles, or associated fractures of bony processes to which are attached muscles that support the joint capsule. In the shoulder, for example, the supraspinatus, infraspinatus, and subscapularis muscles greatly strengthen the joint, therefore detachment of the humeral tuberosities predisposes to recurrence of the primary dislocation. Fractures *may also weaken the joint by destroying the continuity of a strong* cup such as the acetabulum, or by altering the plane of articular action and so permitting the muscles to apply mechanical strains in faulty directions.

(6) If a luxation remains unreduced a new joint tends to form in the position of the dislocated bone; *ligaments and muscles shorten* and adapt themselves. Reduction becomes progressively more difficult owing to closure of the capsular rent, to filling up of the original cavity, to alteration of the articular facets, and to shortening of the muscles and ligaments and other soft tissues.

Clinical features of dislocations generally.—The patient gives a history (if the case be traumatic) of accident or sudden *muscular strain, followed by pain, by swelling and extensive bruising*, by uselessness and a constrained attitude of the limb, and, if nerves are compressed, by paræsthesiæ such as numbness or tingling in the distribution of the affected nerves. On inspection and palpation the altered outline of the part, the changed axis of the limb, its immobility in abnormal position, and *the anomalous relationship of bony* points, will often lead to a diagnosis. A comparison of careful *measurements* between bony points with those of the unaffected side and a radiographic demonstration of the exact position of the bones will

render diagnosis certain. Every dislocated joint should be examined with the X-rays to ascertain the exact position of the bones and the presence or absence of associated fractures.

Treatment.—In all cases reduction should at once be attempted by manipulations designed first to render patent the capsular rent, and then to make the dislocated bone return along its own track. Replacement may be hindered (1) by tense spasm of surrounding muscles, (2) by interposition of the edge of the torn capsule, of ligaments, of tendons, or of muscle between the bones, (3) by locking of bony prominences, or (4) by such damage to bones or to strong parts of capsules (such as the Y-ligament of the hip) that the *point d'appui* is lost for the necessary manipulation.

Maintenance in the reduced position may be rendered difficult (1) by excessive damage to the joint, (2) by the presence of associated fractures, or (3) by anatomical peculiarities.

Muscular spasm may be overcome by general anæsthesia or by steady extension applied by the surgeon directly or through a clove-hitch made of wet towelling whilst counter-extension is exercised by the surgeon, by the patient's weight, or by an assistant; pulley-extension is dangerous. The anæsthetic must be very carefully administered, for, owing to the depth of anæsthesia required and the unprepared condition of the patient, many fatalities have occurred. If carefully planned manipulation under anæsthesia fails to secure reduction, an open operation should be performed under rigidly aseptic precautions as soon as bruising and swelling have disappeared, that is, in about ten to fourteen days. Resisting structures should be divided one after the other, fresh manipulative efforts at reduction being adopted after each step. Occasionally, though rarely except in very old-standing unreduced dislocations or in luxations combined with fractures, excision of the joint may be necessary.

The *after-treatment* in all cases consists in the use of a retaining and supporting apparatus combined with the early application of massage and passive movements. Gentle effleurage may be begun at once, and pétrissage of a gradually deepening character added from day to day. Passive movements of the joint may be very gently commenced as early as the fourth or fifth day, while active movements should in most cases not be allowed until the third week.

Old-standing, unreduced dislocation.—If for any reason the dislocation is left unreduced, the true joint becomes filled with fibrous tissue, the cartilages tend to degenerate into fibrous tissue, and the displaced head either becomes firmly fixed by strong adhesions, or burrows a new joint-cavity and corresponding articular facet on the apposed base and so forms a false joint (pseudarthrosis). Chronic arthritis remoulds the head and the false facet, partly by atrophy at

points of pressure and partly by hypertrophy at the edges, until t lose all resemblance to the original shape. Surrounding cicatrizat may compress nerve trunks, muscles may undergo contractures, tendons may develop fresh attachments. As a broad rule, red *tion by manipulation* under an anæsthetic may be cautiously u till about two months after the accident; after that, open operati is necessary. The joint may be reconstituted and the head placed, but not infrequently excision of the head is demanded. T use of pulleys and levers is dangerous and should be abandoned.

Dislocations **complicated by fracture** often require operatio the dislocation being reduced and the separated fragments fixed position by some mechanical device; in some cases excision advisable.

Compound dislocations should be opened up, thorough cleansed, and reduced. If the purification be thorough and the joi left dry, drainage should be omitted, but careful watch must be kep lest suppuration occur. If there be oozing, drainage for twenty-fo hours is advisable.

2. CONGENITAL DISLOCATIONS

These occur before birth, but are often aggravated during extra-uterin life by use in the faulty attitude. Although occasionally, but rarely, see in the shoulder and other large joints, they are only common in the hip Congenital dislocation of that joint is fully discussed at p. 1097.

3. PATHOLOGICAL DISLOCATIONS

Among the chief factors making for articular strength are the *integrity of the joint surfaces and the tone of ligaments and muscles.* If disease have weakened any of these, whether by deformity or destruction of bony surfaces, by atony or paralysis of muscles, or by over-distension and slackening of ligaments, dislocation will readily occur. As a rule, in pathological luxations several such agents are at work, though usually one predominates. Thus, in the disloca-tions occasionally seen in association with enteric fever, with the various exanthemata, with pneumonia and gonorrhœa, over-distension is the chief factor causing laxity of the ligaments and separation of joint surfaces. But in addition there is often some muscular atony, and sometimes destruction of articular surfaces

As an example of dislocation chiefly attributable to loss of mus-cular power, the luxations occasionally seen in infantile paralysis may be cited. In the dislocations of *neuropathic arthropathies*, and in arthritis deformans, bony deformation plays an important part with the aid of muscular atrophy, and sometimes of fibro-cicatricial contractures (as in rheumatoid arthritis) or of excessive effusion (as in some cases of Charcot's disease).

Destruction of bony surfaces may be seen in tuberculosis, osteomyelitis, and some cases of malignant disease; in tuberculosis of the hip, for instance, erosion of the femoral head and the acetabular edge, with the assistance of ligamentous weakening, muscular contraction, the faulty attitude, and to some extent the presence of effusion, may eventually lead to dislocation.

The **treatment** of pathological dislocations calls for the use of apparatus to prevent future dislocations and for the treatment of the underlying disease, as well as the ordinary reduction and retention of the displaced bones.

DISLOCATION OF THE CLAVICLE

Any dislocation of the clavicle is rare. The acromial end suffers more frequently than the sternal.

1. The **acromial end** of the clavicle may be displaced in either (a) a superior, (b) a postero-inferior, (c) an antero-inferior, or (d) a backward direction.

(a) **Superior.**—As a result of a sudden downward force applied to the acromion, probably often helped by sudden strong traction of the trapezius, the outer clavicular end rides upwards over the acromion, and the acromioclavicular ligaments are torn. If the coraco-clavicular ligaments hold, the dislocation is incomplete, but if they give way it becomes complete. The displaced clavicular extremity can be felt above the acromion; the deformity is obviously at the end of the clavicle and not in its course; the joint is swollen and painful; crepitus is absent, and radiographic examination confirms the diagnosis.

Treatment.—The bone is readily replaced by raising the shoulder and pressing the clavicle downwards; it is maintained in position by placing a pad over the outer end of the clavicle and fixing a broad plaster or bandage figure-of eight around the elbow, crossing over the pad and then across the chest and back. By this means the arm is elevated and the outer end of the clavicle depressed. The arm should then be fixed to the side by a bandage. If deformity is marked, and complete laceration of the coraco-clavicular ligaments probable, operation for the replacement and fixation of the clavicle and acromion is often advisable.

The other dislocations of the acromial end of the clavicle are very rare.

(b) In the **postero-inferior displacements** the end of the clavicle is driven downwards to a position below the acromion by a downward force applied when the arm is abducted. The clavicle is felt in its abnormal position, the arm is more or less fixed, and the brachial plexus may be compressed.

Treatment.—The dislocation is reduced by adducting the arm and pulling and levering the shoulder outwards while the clavicle is pressed upwards. If the arm be bound to the side over an axillary pad of wool, the dislocation does not readily recur. But undue pressure on the axillary vessels must be avoided.

(c) A few cases of **antero-inferior dislocation** are recorded, in which the clavicular end is found below the coracoid process in the axilla.

(d) Still more rare is the **backward** variety, in which the clavicular end passes into the supraspinous fossa.

2. The **sternal end of the clavicle** may be displaced (*a*) forwards, (*b*) upwards, or (*c*) backwards, in that order of frequency.

(*a*) **Forward dislocation.**—As the result of a sudden strong force driving the shoulder backwards, as in a fall on to the shoulder or on the rigidly outstretched arm, the sterno-clavicular ligaments are torn and the head of the clavicle driven forwards and slightly downwards and inwards on to the sternum. The projecting head, moving with the arm, can be felt beneath the skin.

Treatment.—To effect reduction the surgeon stands behind the seated patient, places his knee between the scapulæ and pulls the shoulder strongly backwards, while an assistant presses on the escaped clavicular head; to prevent recurrence he fixes a pad over the sterno-clavicular joint by means of strapping or a bandage. Sometimes this means is insufficient for the maintenance of the reduced position; if so, or if the dislocation has recurred on several occasions, wiring of the clavicle to the sternum by open operation should be adopted.

(*b*) **Dislocation upwards** occasionally happens, the head of the clavicle being levered upwards through the capsular rent by a sudden depressing force applied to the outer end of the bone. The head passes upwards and inwards, and may cause severe pressure on the trachea and œsophagus.

Reduction is usually easy by a manœuvre analogous to that described for the anterior dislocation. The corrected position is maintained by a strapping or a bandage over a pad.

(*c*) **Dislocation backwards** is very rare; it is usually due to direct violence, and is not infrequently associated with fracture of the upper ribs. The clavicular head passes inwards behind the sternum, and the shoulder is projected forwards; the pressure on large vessels and on the trachea may cause serious cyanosis, alteration in the pulse, and dyspnœa; and cervical and brachial movements are painful and restricted.

Treatment.—Reduction is secured by placing the knee between the scapulæ and pulling the shoulders backwards; recurrence is prevented by strapping the arm to the trunk in such a way that the shoulder is pulled downwards and backwards. It is also advisable to keep the patient in bed on his back, with a narrow sand-bag between his shoulders. If reduction or retention is difficult, an open operation should be performed and the clavicle wired to the sternum. In one [illegible]
of the clavicle into the abnorm[illegible]
the shoulders in *padded rings*, [illegible]
from ring to ring across the ba[illegible]
sterno-clavicular joint.

DISLOCATION OF THE SHOULDER

The shoulder is dislocated nearly as often as all the other joints taken together. The displacement may occur—(*a*) forwards, into the subcoracoid or a subclavicular position; (*b*) downwards, into a subglenoid position; (*c*) backwards, into a subacromial or subspinous position. An upward dislocation into the supraglenoid position has also been described.

Etiology and mechanism.—It occurs most frequently in males at or above middle life, and is comparatively rare in youth. The shape of the joint surfaces and the great range of movements

possible at the shoulder strongly predisposes to dislocation; thus the large, smooth, globular head of the humerus rests in a shallow glenoid cavity without any real bony support; moreover, the capsule is lax and the joint depends largely on the muscles for its strength.

Although it may result from direct violence, or from sudden insufficiently controlled muscular effort, as in throwing a cricket-ball, or sometimes during epileptic attacks, dislocation at this joint most often follows indirect violence with outstretched arm in the abducted position. By a fall with the arm in this position the great tuberosity is driven against the upper edge of the glenoid; a continuance of the forcible abduction of the arm now levers the head of the humerus downwards and through the weakest part of the capsule, namely its lower and inner portion. The head may remain in this subglenoid position, but most frequently is still further displaced by the continued action of the initial violence, by muscular traction, by the falling of the arm to the side under the influence of gravity, and sometimes by the misguided efforts of bystanders.

Usually after resting very temporarily on the glenoid edge the head passes upwards and forwards to lie below the coracoid process (*subcoracoid dislocation*), or sometimes below the clavicle (*subclavicular*). In other cases it passes backwards and upwards to constitute a *subacromial* or a *subspinous luxation*. Occasionally it remains in the subglenoid position (*subglenoid dislocation*); an extreme form of this is the *erect dislocation*, in which the arm remains in an exaggeratedly hyperabducted position and cannot be brought to the side.

Dislocation of the shoulder is a serious condition, because recurrences are not infrequent, and because it is quite commonly complicated by fractures in the neighbourhood. Either as a result or as a cause of recurrent dislocations the capsule may be so relaxed and the supporting muscles so atonic that the shoulder slips out on the performance of quite ordinary movements. Recurrences are especially liable to occur if the rotator muscles, such as the spinati, the teres minor, or the subscapularis, are lacerated, or if the tuberosities to which they are attached are torn off. This latter accident also renders the maintenance of a reduced position difficult, and in some cases may actually prevent reduction. The head of the bone usually passes out between the scapular head of the triceps and the subscapularis. Separation of the great tuberosity, combined with a displacement of the long biceps tendon, which may become wound round the neck of the bone or interposed between the tuberosity and the head, forms a very effectual barrier to reduction.

Every case of dislocation of the shoulder should be examined by radiography, preferably stereoscopically, not only accurately to determine the position of the head, but also to ascertain the existence

of associated fractures. The fractures most commonly found are the following, viz. surgical neck, separation of the great tuberosity, anatomical neck, separation of the lesser tuberosity, fracture of the glenoid. Injury to the neighbouring vessels and nerves, although common enough to call for caution in handling, is relatively rare in recent dislocations. The subscapular vessels may possibly be lacerated, the brachial plexus pressed upon or overstretched, or the circumflex nerve damaged. These lesions are, however, commoner during attempts to reduce old-standing dislocations; care must especially be taken, therefore, in such cases.

Clinical features.—The patient gives a history of an accident or a sudden strain, usually of a fall with the arm extended and abducted. Occasionally, however, the displacement may occur during some violent and uncontrolled muscular action. In two of my cases it resulted from a sudden unexpected uplifting of the body by the arm extended above the head.[1]

Complete mobility of the joint is lost. The elbow is usually held away from the side, and in the ordinary anterior varieties the normally rounded contour of the point of the shoulder is flattened, and the acromion is too obviously prominent, so that a ruler placed against the outer aspect of the arm will simultaneously make contact with the *acromion* and the *external epicondyle of the humerus* (*Hamilton's test*) in a manner impossible in a normal arm; this test is also positive in some fractures of the anatomical neck of the humerus. Palpation and radiographic examination demonstrate the anomalous situation of the humeral head, and the presence or absence of associated fractures. Pain is often referred along the brachial nerves. The observer frequently finds it impossible to bring the elbow of the affected arm to the side, or the hand on to the front of the opposite shoulder, whilst the elbow of the affected side is held close to the trunk (Dugas's sign); but if there be great tearing of the capsule, fracture of the neck, or separation of the great tuberosity, the immobility, the abduction of the arm, and Dugas's test may fail to be obvious. There is evident lowering of the anterior or the posterior fold of the axilla (Bryant's test), and increase of the vertical measurement of the axilla (Callaway's test) as compared with the other side.

(*a*) **Forward dislocation.** i. *Subcoracoid dislocation* is the commonest variety; in it the head lies against the front of the scapular neck, below the coracoid process, medial to the anterior edge of the glenoid, and above the tendon of the subscapularis. This muscle

may be lacerated or may form a tight band across the humeral neck that interferes with reduction. Supraspinatus, infraspinatus, and teres minor may be tight and cause external rotation of the arm, or they may be torn, or the great tuberosity, to which they are attached, *may be broken off. The acromion is unduly prominent, the elbow* is abducted and cannot be brought to the side, mobility is lost, and Dugas's sign is present. The displaced head is seen and felt below the coracoid process; the length of the arm is not much changed.

ii. *Subclavicular dislocation* is not at all common. The shoulder is even more flattened than in the former case. The head is felt below the outer end of the clavicle under the pectorales; loss of mobility and Dugas's sign are present; the arm is definitely shortened.

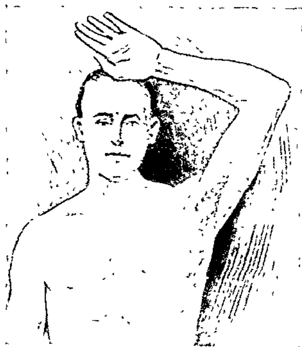


Fig. 870.—Luxatio erecta.

(*b*) **Downward dislocation (subglenoid).** — The signs are similar to those already detailed, but the head is found in the axilla; it rests against the lower margin of the glenoid, or against the axillary border of the scapula, in front of the scapular head of the triceps, below the subscapularis and above the teres minor. The flattening of the shoulder and the abduction of the elbow are more marked, *and there is very distinct depression below the tip of the acromion. The anterior fold of the* axilla is unduly deep; and the measurement between the tip of the acromion and the external epicondyle is greater than in the other arm.

Subglenoid dislocation is a step in the production of the other varieties, but it persists comparatively rarely.

Luxatio erecta is a rare sub-variety, in which the arm has been so far abducted that it becomes locked in a position above the head. (Fig. 870.)

of associated fractures. The fractures most commonly found are the following, viz. surgical neck, separation of the great tuberosity, anatomical neck, separation of the lesser tuberosity, fracture of the glenoid. Injury to the neighbouring vessels and nerves, although common enough to call for caution in handling, is relatively rare in recent dislocations. The subscapular vessels may possibly be lacerated, the brachial plexus pressed upon or overstretched, or the circumflex nerve damaged. These lesions are, however, commoner during attempts to reduce old-standing dislocations; care must especially be taken, therefore, in such cases.

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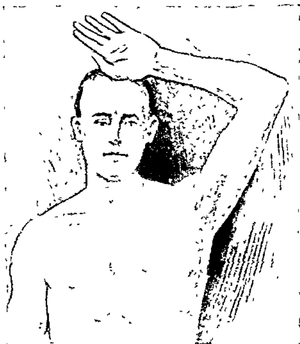


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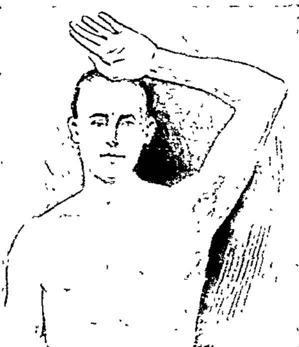


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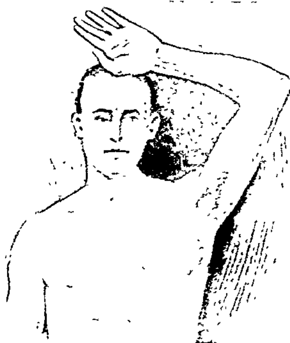


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the arm, and then gradually adducts it over his heel, while maintaining a steady traction

ii. *Hyperextension*.—In some cases reduction may be effected by raising the arm into the erect, hyperextended position, exercising traction, and then bringing the arm back to the side.

Neither of these two methods is so rational or so satisfactory as Kocher's manipulation; they more often fail, and also expose axillary vessels and nerves to greater danger of direct injury or of overstretching than does the properly executed manipulation. *A certain risk of fracturing the humeral neck in Kocher's method is overcome if the first and second manœuvres be performed very slowly.*



Fig. 874.—Kocher's method: rotation inwards, the hand being carried towards the *opposite shoulder.*

The use of pulleys and heavy weights is to be condemned. If reduction by the above methods fails under anæsthesia, open arthrotomy, permitting replacement of displaced and interposed structures, is the procedure to be advised.

The **after-treatment** is very important. The arm should be bandaged *to the side* and kept at rest for four days, any massage applied being only a soothing and *superficial effleurage to reduce swelling* and relieve pain. On the fourth day gentle rotary passive movements *should be adopted. Then, day by* day, movements of wider range should be adopted, those of strong abduction and circumduction *being reserved to the last. After the* sixth day the bandage should be worn only during sleep, the arm being supported by a sling during the day. After three weeks, gentle *active movements are allowed, and the sling is abolished in about four weeks* At the end of that period the patient should be encouraged to use the shoulder freely; gymnastic exercises, such as the turning of a wheel with a wide diameter, or the gradual application of body-*weight* while the hand clasps a bar above the level of the head, are useful.

2. **Treatment of fracture-dislocation.** — *Under an anæsthetic*, reduction of both dislocation and fracture should be attempted. If this fail, an open operation should be performed, interposed structures replaced, the dislocated head reduced *by manipulation or by the use of hooks*, and the fracture mended by

screwing, suturing, or sometimes by plating. In this way the amount of callus will be reduced and the best results obtained.

In many cases excision of the detached and dislocated head is required; this operation, if followed by adequate after-treatment, often gives good functional results. A separated greater tuberosity may be refixed by pegging or screwing.

Unreduced dislocations of old standing are sometimes seen in the shoulder. Those of not more than two months' duration may often be reduced by manipulation, but require especial care, for many accidents have occurred; the commonest catastrophes during reduction have been fracture of the surgical neck and laceration of the brachial nerves or large axillary vessels.

The necessary manipulations must be performed very slowly; if they are not readily successful an anterior incision should be made from the outer side of the coracoid process downwards and outwards parallel to the anterior border of the deltoid, and the joint opened, manipulations being made afresh as each obstructing structure is divided. Adhesions must be divided with due regard to included vessels and nerves, the glenoid cavity cleared, the biceps tendon replaced in its groove if it be displaced, fractured tuberosities fixed, and tense contracted rotator muscles stretched or divided. If the head be still unreducible or if it be separated from the shaft, it should be excised. Occasionally difficulty of access may be overcome by cutting through the coracoid process and turning it aside; at the end of the operation the detached tip of the process is refixed by wiring.

In the **after-treatment** rest is advisable for ten days, followed by gradually increasing massage and passive movements, and eventually by active movements.

Recurrent dislocation is best treated by operation. If the capsule is redundant and flaccid, it may be plicated by catgut sutures or a wedge-shaped portion excised. If the laxity is due to separation of the tuberosities or to tearing away of the insertions of the spinati, teres minor, or subscapularis, these should be fastened back into position.

Recurrence due to fracture or alteration in shape of the glenoid cavity is more difficult to treat, but an attempt may be made by gouging to remould the glenoid into a more cup-shaped surface.

DISLOCATION OF THE ELBOW

Dislocation of the elbow occurs with a frequency only second to dislocations of the shoulder and fingers. Young adults and children are affected more often than those past middle age, and, as in the case of all dislocations, males are more often so injured than females.

Either the radius or the ulna may be dislocated alone, or both bones may be displaced together.

Dislocation of both bones.—The commonest dislocation of both bones is backwards. Lateral dislocations are distinctly uncommon and forward displacements rare.

Another rare form is the divergent, in which the radius and the ulna pass in different directions.

(a) Backward displacement.—This luxation usually occurs as *the result of a fall* on to the hand while the elbow is extended. The olecranon process becomes firmly engaged in the olecranon fossa, and *forms the fulcrum of a lever; hyperextension of the elbow* occurs, the anterior and internal lateral ligaments are ruptured, and the ulna, followed by the radius, is driven backwards; the coronoid process may slip into the olecranon fossa and lock the joint, or it may become fractured and allow freer movement, with crepitus. The external lateral ligament is also very frequently lacerated. The main vessels and nerves are occasionally, but rarely, injured. The brachialis anticus may be torn and a fragment of it interposed between the bones. The common flexor origin is occasionally separated from the humerus. Association with fracture is common; the coronoid process is frequently detached, but in addition there may be fracture of the external or internal epicondyle or a fissure in the head of the radius.

Clinical features.—Swelling rapidly increases, and may confuse the diagnosis; but if the limb be examined before great swelling has occurred, determination of the character of the lesion is easy. The *elbow looks widened from before backwards, the forearm is shortened,* and a prominence is formed in front by the lower end of the humerus and behind by the radius and ulna.

The forearm is held in a position midway between pronation and supination, or is slightly supinated; the elbow is somewhat flexed, but full flexion or extension is impossible, although lateral mobility is abnormally free. When the limb is extended as far as possible, *the tip of the olecranon rises above the transcondylar line.* This fact helps to distinguish the lesion from a supracondylar fracture. On palpation and comparison with the other elbow the altered relationships of the bony points are obvious, whilst radiography establishes the exact position of the bones and the presence or absence of a complicating fracture.

Treatment.—Reduction is usually easy, unless a bony fragment or *some soft tissue is interposed.* The surgeon stands in front of the seated patient and, with one of his feet upon a *chair, grasps the* patient's arm above and below the elbow. (Fig. 875) He then slowly, but strongly, flexes the elbow round his knee, at the same time exer-

cising traction on the forearm and pressure with his other hand upon the olecranon. If this method fail, the patient should be anæsthetized and an assistant secured to fix the humerus while the surgeon successively supinates the forearm, extends the elbow, and then simultaneously pulls forward and flexes the forearm.

If massage be begun after two days and gentle passive movements in seven to ten days the results are generally good; but the brachialis anticus is one of the muscles most likely, after injury, to undergo myositis ossificans; therefore strenuous passive or active movements should not be made till three to four weeks after the dislocation, and the possibility of myositis ossificans must be remembered in giving a prognosis.



Fig. 875.—Reduction of backward dislocation of elbow.

(*b*) Both bones laterally.—This dislocation is uncommon, and when present is generally associated with a fracture of one or other epicondyle and a backward dislocation. It is generally incomplete, only an occasional external displacement being complete.

Diagnosis can always be made by palpation and by radiography.

Treatment. — The displacement can be reduced by hyperextension and traction, followed by flexion, combined with pressure on the head of the radius. If this be impossible, open arthrotomy must be performed.

(*c*) Both bones forwards.—This rare dislocation may be caused by a fall with the elbow flexed: the lower end of the humerus projects backwards; the olecranon fossa feels empty unless, as is often the case, the olecranon process has been detached, and with this exception the olecranon is felt either beneath or in front of the lower end of the humerus when the elbow is flexed. The triceps is torn.

Treatment.—Reduction may be effected by traction combined with downward and backward pressure on the upper part of the forearm, or it may be done by the knee-in-elbow method.

If the olecranon process be fractured it should be replaced and wired into position.

(*d*) Divergent dislocations may occur either in an antero-posterior direction, in which the radius passes forwards and the ulna backwards, or in a transverse manner, when the radius passes outwards and the ulna inwards. Both types are rare Diagnosis is made by palpation and by radiography.

In *treatment* each bone should be reduced separately.

After-treatment of all varieties.—The limb should be placed in a *rectangular posterior gutter splint*, with the elbow flexed at a right angle. Slight massage may be commenced at once, and passive movements after seven days, the splint replaced by a sling in the day-time after three weeks, and more extensive passive movements and stronger *massage then encouraged.*

Active movements may be begun in four weeks.

Dislocation of the ulna alone.—As the result of a forcible twist or of a fall on the inner side of the hand or forearm, the ulna alone may be displaced backwards, or exceedingly rarely inwards or forwards. In the posterior dislocation the tip of the coronoid process rests above the trochlea or in the olecranon fossa, while the head of the radius can be felt in its proper place.

Reduction is secured by the method adopted for dislocation of both bones backwards.

Dislocation of radius alone (Fig. 876).—This dislocation is comparatively common. The radius slips forwards, and the ulna is often

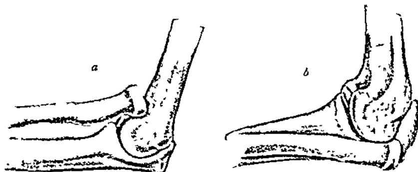


Fig. 876.—Dislocation of radius (*a*) forwards, (*b*) backwards.

simultaneously fractured in its upper part. The radial head is palpable in front of the lower end of the humerus above the *capitellum, and its normal position is obviously empty. The forearm* is held between pronation and supination, and partly flexed on the arm, but further flexion and supination are impossible, although pronation is free. Very rarely, instead of this forward displacement, *dislocation backwards, or even more rarely dislocation* outwards, may be seen.

Treatment.—The head can usually be replaced by traction and by backward pressure, occasionally the capsule is interposed; in such case open *arthrotomy is often necessary before* reduction can be accomplished. The elbow [illegible] and the forearm must [illegible] ould be beg[illegible] of [illegible] ligament before any free movements are permitted.

[illegible] of the radius (pulled elbow).—This is [illegible] sudden pull on the [illegible] orbicular ligament,

dramatic cure is effected by fully flexing and then extending and completely supinating the forearm.

Old-standing dislocation of the elbow.—The diagnosis of dislocated elbow may be missed, owing to swelling of the parts and the failure in such cases to use X-rays; or reduction may be impossible, owing to the interposition of fragments of bone such as detached epicondyles, of capsule, or of muscles such as the brachialis anticus.

Reduction by manipulation is usually impossible after about six weeks; it is then advisable to open the joint—either by a posterior incision passing over the tip of the olecranon from a point 2 in. above to 2 in. below the point of the elbow, and splitting the triceps longitudinally; or by Kocher's J-shaped incision, which passes vertically down to the outer side of the olecranon and then curves inwards 2 in. below it. Abnormally placed and taut structures are replaced and relaxed, or if necessary removed, and the dislocation reduced.

In the worst cases, excision of the joint or of the head of the radius is sometimes necessary.

Fracture-dislocation of the elbow.—Dislocations here are very often complicated by fracture, either of the olecranon, of the coronoid,

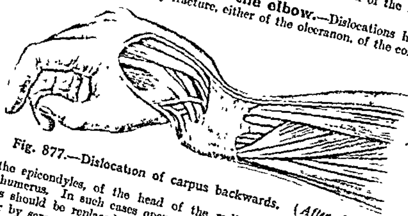


Fig. 877.—Dislocation of carpus backwards. (*After Anger.*)

of the epicondyles, of the head of the radius, or of the lower end of the humerus. In such cases open operation will often be necessary. The bones should be replaced in their normal position and fragments secured either by screws, plates, or wires. In all such cases massage and passive movements should be commenced early.

DISLOCATIONS IN THE WRIST AND HAND

Dislocation of the inferior radio-ulnar joint may occur either backwards or forwards, but is very uncommon; it may follow direct violence or excessive pronation or supination. The lower end of the ulna is felt and seen projecting at the back or in front of the wrist, according to the variety of dislocation. Reduction is secured by direct pressure correcting the deformity.

Dislocation of the radio-carpal joint is also rare. The carpus may be driven *backwards* and cause a prominent swelling dorsally (Fig 877); the deformity is distinguished from a Colles's fracture by the more abrupt declivity of the swelling, by the normal level of the radial styloid process, and by the radiographic appearance. The dislocation is reduced by pressing the carpus forwards while pulling on the hand an alternately flexing and extending the wrist.

Occasionally, the carpus is driven *forwards* and produces posterior hollowing and anterior prominence of the wrist. Reduction is effected by a manœuvre similar to that for backward displacement.

Madelung's deformity (*spontaneous luxation of the wrist*) is a rare condition, often involving both wrists, and especially attacking females between 15 and 25. The hand becomes displaced towards the palm, and the *ulnar head is unduly prominent*. *Flexion is readily performed, but rotation and hyperextension are difficult and often painful.* Pain may be present apart from movement. The radius shows a dorsal *convex curve in its lower part*. *Reduction is only possible in the early stages, if at all.* Congenital changes followed by slight injury, late rickets, and rarefying osteitis have been blamed as causes.

Treatment.—The wrist may be massaged and kept hyperextended by splints. If this fail, osteotomy of the radius may be advisable.

Dislocation at the midcarpal line of joints is exceedingly rare; it can be reduced by local pressure, combined with traction and alternate flexion and extension.

Any one carpal bone may be displaced, but the **semilunar** is the most commonly dislocated.

Anterior dislocation of the semilunar is relatively frequent. It projects on the front of the wrist under the flexor tendon, and causes a corresponding posterior depression between the radius and the os magnum, the latter therefore appearing unduly prominent. The fingers are held immobile in partial flexion; attempts to move them cause pain. The palm appears shorter than its fellow.

This dislocation is often complicated by fracture of the scaphoid, an accident shown by X-rays to have frequently been present in cases formerly diagnosed as sprained wrist. When this complication is present one fragment *of the scaphoid is generally dislocated with the semilunar*.

The deformity is usually easily reduced by hyperextending and then strongly flexing the wrist, pressing firmly over the displaced bone, while the wrist is held by an assistant. If this manipulation persistently fail, the semilunar (with a fragment of scaphoid if there be a fracture) should be excised.

(... **ons** are very rare; they may
... commoner in the thumb than in
... gnosis from Bennett's fracture.
... re.

... **arpo-phalangeal joints**
... readily made, and, except in the
... ension and manipulation.

... **rpo-phalangeal joint of the thumb** is of great interest from its relative frequency and from the difficulty experienced in reduction. The phalanx is displaced backwards and outwards, so that the head of the metacarpal bone projects forwards between the two heads of the flexor brevis pollicis; the glenoid ligament slips back with the phalanx and the sesamoid bones of the short flexor to a position behind the metacarpal head, and the tendon of the flexor longus pollicis winds itself round the neck of that bone. The two latter factors determine the difficulty in replacement. The former teaching that the head was locked by the flexor brevis was incorrect; the chief blame must be allotted to the interposition of the glenoid ligament between the bones.

Treatment.—Reduction should first be attempted by manipulation. The surgeon grasps the thumb in a Japanese toy thumb-screw, or, if that be

not available, in a clove-hitch of narrow bandage; pulling on the thumb, he hyperextends the metacarpo-phalangeal joint to a right angle, and then suddenly flexes the thumb into the palm, while pressing the metacarpal outwards. If this manœuvre fail, he should tenotomize the glenoid ligament between the two sesamoid bones by inserting a fine knife posteriorly just above the phalanx and passing it forwards until it reaches the ligament. Reduction is then easy.

Dislocations at the [illegible]
diagnose. They are reduced
with the aid of a thumb-screw
extending, pulling, and flexing.

DISLOCATION OF THE HIP

Dislocation of the hip results from sudden and excessive abduction of the thigh. It may thus follow a sudden wide separation of the legs, or a fall of coal on to the back of a miner working in a constrained attitude with the thigh abducted. Owing to the great bony, ligamentous, and muscular strength of the joint, this luxation is comparatively uncommon, and correspondingly difficult to reduce. It occurs chiefly in young adults before the femoral neck has become brittle; after the age of 45 fracture is more probable.

During abduction the ligamentum teres is relaxed and the femoral head approximates to the postero-inferior or weakest part of the capsule. By sudden hyperabduction the caput femoris is driven through the capsule here, and then passes on in a direction which is determined—(1) by the direction of the initial violence; (2) by the position of the leg at the time of the accident, whether flexed and inverted, or extended and everted; (3) by subsequent movements by the patient or manipulations by onlookers; (4) by the integrity or rupture of the anterior Y-shaped ligament of Bigelow, and (5) of the obturator internus tendon.

Posterior dislocations follow the application of a force when the limb is in a position of flexion and internal rotation; anterior dislocations, when it is extended and externally rotated.

If Bigelow's ligament be torn, the head is freely movable in different directions, and recurrence after reduction is frequent; such a dislocation is termed *irregular*.

If the Y-shaped ligament is intact the dislocation is said to be *regular*, and the head is fixed in one of four definite positions, viz.:

Backwards
- (*a*) *Dorsal*, above the level of the torn obturator internus; about 50 per cent.
- (*b*) *Sciatic*, below the intact obturator; about 25 per cent.

Forwards
- (*c*) *Obturator* or *thyroid*, into the obturator notch; about 15 per cent.
- (*d*) *Pubic*, on to the pubic ramus; about 10 per cent.

Although dislocation most frequently occurs during abduction, it may happen with the thigh adducted; by strong inversion and over-adduction the head is then driven directly backwards, usually above the obturator tendon. The acetabular rim is often fractured.

A. Regular dislocations (*ilio-femoral or Y-ligament intact*).
I. Backward.—The ligamentum teres is torn, the capsule gives way usually postero-inferiorly, and *the external rotators and pectineus* muscles are often ruptured. If, as is more usual, *the dislocation be due to forcible abduction, the tear in the capsule tends to be below the obturator internus tendon; if it be due to excessive adduction*

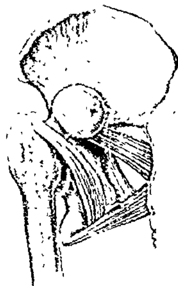


Fig. 878.—Dorsal dislocation of hip. (*After Pick.*)

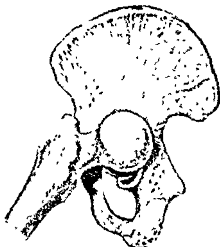


Fig. 879.—Sciatic dislocation of hip. (*After Pick*)

the rent is often above the tendon; laceration of the tendon often follows. The femoral head passes backwards, where in thin subjects *it may be felt.* The great *sciatic nerve is often compressed, and pain* and paræsthesia may be conspicuous features.

i. *Dislocation on to the dorsum ilii* (dorsal dislocation) (Fig. 878).—The head lies on the dorsum ilii *above the obturator internus* tendon, which is often ruptured. The joint is locked and immobile; Scarpa's triangle feels empty; *the great trochanter is raised above* Nélaton's line; *the leg is considerably shortened and is held in a* position of adduction, inversion, and flexion, so that the thigh crosses *its fellow well above the knee.* (Fig. 880.) The knee is flexed, the heel raised, *and the ball of the great toe reclines on the other foot.*

(*b*) *Sciatic dislocation* ("dorsal dislocation below the tendon" of

Astley Cooper) (Fig. 879).—The head lies in the region of the sciatic notch, below the intact obturator internus tendon. The clinical features are *similar to those of a dorsal* dislocation, but are less exaggerated. The great toe rests nearer its fellow, in the instep; shortening is *much less* conspicuous; and the femur crosses the other knee. (Fig. 881.)



Fig. 880.—Dorsal dislocation of hip.

Diagnosis of backward dislocation is usually easily made from the history of the accident, the age of the patient, the immobility of the limb, the physical signs already detailed, the radiographic evidence, and the absence of crepitus and of broadening of the great trochanter (unless fracture be also present).

Treatment.—The dislocation can usually be reduced by *manipulation.* The patient is placed on the floor and anæsthetized; then, with an assistant firmly fixing the pelvis, the surgeon gradually but fully flexes the knee and hip, while still keeping the thigh adducted towards the middle line. (Fig. 882.) After holding the limb in this position for a minute or two, he quickly circumducts it outwards in a wide circle and extends it to lie parallel to its fellow. The capsular wound is thus made to gape, the tense structures are relaxed, and the head is then caused to retrace its path into the joint cavity; in the later steps the ligament of Bigelow acts as a fulcrum.



Fig. 881.—Sciatic dislocation of hip.

Occasionally this method fails. The

surgeon may then try direct traction with the hip flexed to a right angle. While an assistant firmly fixes the pelvis, the surgeon stands over the patient and flexes the hip and knee to right angles, so that the patient's shin rests against his perineum; then, passing his elbows beneath the knees and grasping the thigh, he pulls powerfully upwards or reapplies the Bigelow manœuvre *(just described)* whilst *maintaining strong traction. An additional grasp may be obtained* by means of a roller-towel clove-hitch. (Fig. 883.)

Rarely, in very muscular patients, reduction is impossible, even

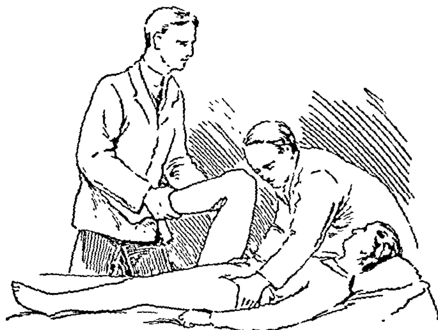


Fig. 882.—Flexion, abduction, and rotation outwards, in dorsal dislocation of hip.

under anæsthesia, until the muscles have been tired out by the traction of weights applied over a pulley; the extension is applied in the direction of the displace[illegible] and counter-exten[illegible] tained by means of a padded perin[illegible] fixed to the head [illegible]ed.

2. Forward dislocatio[illegible] the head passes [illegible] and many of the signs applicabl[illegible] rd dislocati[illegible] The joint is fixed and the l[illegible] flexed, but t[illegible] is less prominent than [illegible] gh is abdu[illegible] ed in[illegible] ing adducted a[illegible]

[illegible] *or dislocation.* [illegible] slight[illegible]

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on the obturator nerve may cause considerable pain. The pectineus and adductor muscles are stretched or torn, the capsule and ligamentum teres are ruptured, and the obturator nerve may be compressed. Abduction and eversion are less conspicuous than in the next variety of dislocation. The leg shows both real and apparent lengthening (Fig. 884), but occasionally the patient manages to walk, stooping forwards to relax the taut ilio-psoas.

(*b*) *Pubic dislocation.*—The head leaves the capsule below, or occasionally, by hyperextension, is driven through in front to the inner



Fig. 883.—Forcible lifting of flexed femur in dorsal dislocation.

side of the Y-ligament, and comes to rest on the horizontal ramus of the pubes, where it is readily palpable. The capsule and ligamentum teres are torn, the femoral vessels displaced inwards, and the anterior crural is often compressed; severe pain may be felt in the area of its distribution. The limb is shortened and markedly everted and abducted (Fig. 885); the thigh is slightly flexed on the trunk; and the trochanteric prominence may be replaced by a depression.

Diagnosis is readily made by the physical signs and by radiography.

Treatment.—Treatment is analogous to that for backward displacements, but flexion in the *abducted* position followed by circumduction *inwards* and by extension are obviously required.

After-treatment.—In all cases after reduction the legs should be tied together for about ten days. Rest in bed is necessary for

from six to eight weeks. Gentle massage of an effleurage type may be begun at once. Cautious passive movements may be begun in from ten to fourteen days, flexion and extension *only* being

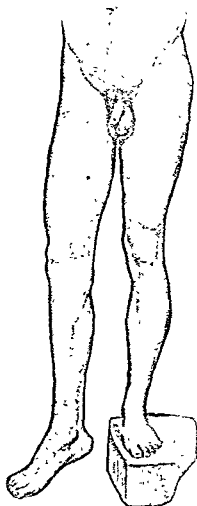


Fig. 884.—Obturator dislocation of right hip.



Fig. 885.—Pubic dislocation of right hip.

used at first. Gentle voluntary movements may be commenced in from three to four weeks. With these precautions recurrences are not common unless the acetabulum should be fractured or the Y-ligament torn.

B. **Irregular dislocations.**—In these the ilio-femoral or Y-shaped ligament of Bigelow is torn, and the femoral head thereby permitted freer excursions. Reduction is usually readily performed.

but maintenance in position is sometimes difficult and convalescence therefore necessarily prolonged.

DISLOCATIONS IN THE REGION OF THE KNEE

Dislocation of the knee may occur either laterally, forwards or backwards.

Lateral dislocation, when it occurs, is usually traumatic, and is generally incomplete. The leg is displaced to one or other side, and is usually slightly rotated and somewhat flexed. The deformity is easily reduced; the after-treatment consists of rest in splints, while to reduce effusion massage may be commenced when it ceases to cause pain. For some months an apparatus that permits only flexion and straightening should be worn.

Forward displacement of the leg on the thigh is usually complete, and is then a serious accident, for the pressure of the lower end of the femur on the popliteal vessels may cause gangrene of the leg. Reduction by traction and manipulation with the knee flexed is generally easy; afterwards complete rest in splints for three weeks should be enjoined, followed by massage and passive movements.

Backward displacement of the leg at the knee is not uncommon in pathological, but is rare in traumatic luxations. If due to trauma, the dislocation is generally complete; the tibia passes backwards behind the femur, and by its pressure on the vessels is very apt to induce gangrene below. Its treatment is analogous to that of forward dislocation.

For **dislocation of the semilunar cartilage**, *see* under Internal Derangement of the Knee, p. 1008.

The **patella** may be displaced to either side or in a rotary manner, so that its edge presents.

(*a*) **Outward dislocation** is commoner than inward, owing to the natural angle of the leg. It may result from direct violence or, especially in the subjects of genu valgum, from muscular action while the leg is extended. Knock-kneed children occasionally practise the trick of partial dislocation outwards. When the dislocation is complete the patella passes round the outer condyle of the femur, the intercondylar notch is unduly palpable, and the knee looks broadened.

(*b*) **Inward dislocation** is very rare and is due to direct violence; its treatment resembles that of the external variety.

(*c*) **Rotary dislocation**.—In this the patella turns on its long axis, and its inner border engages in the intercondylar notch. Complete rotation back to front has been described.

Treatment of patellar displacement.—Reduction is, as a rule, readily effected by manipulation after extending the knee and

flexing the hip in order to secure relaxation of the quadriceps muscle. Occasionally the inner border becomes locked in the *intercondylar* notch and persistently prevents reduction; an open operation may then be necessary.

To prevent recurrence, genu valgum or other predisposing cause, such as paralysis of the extensor muscles, *should be treated, and a* lateral knee truss or elastic crêpe bandage may be required.

DISLOCATIONS IN THE REGION OF THE ANKLE

The **ankle** may be dislocated outwards, inwards, backwards, forwards, or upwards, in that order of probability. Luxation here is very commonly *associated with fractures of the tibia, fibula, or astragalus; thus,* dislocations *outwards* and *inwards* are practically always secondary to fractures of the tibia or fibula. *Backward* displacement is often, but not always, associated with broken malleoli; the heel is excessively prominent, *and the front part of the foot is shortened. Forward dislocation is* very rare; the spaces beside the tendo Achillis are filled up, the heel projection is lost, and the foot appears lengthened. An *upward* displacement, in which the tarsus is driven up through the inferior tibio-fibular articulation, has been reported.

Diagnosis.—In all cases the diagnosis is easily made by an examination of the bony relationships and by radiography. Associated fractures are very common.

Treatment.—The treatment of lateral dislocation is that of the primary fracture. Backward or forward displacements are reduced by relaxing or dividing the tendo Achillis and then exercising traction. The

movements.

The **astragalus** may be partially or completely displaced, either forwards or, much less commonly, backwards. Its dislocations are often compound.

Dorsal or forward dislocation is usually associated with some *rotation, most often outwards. The bone may rest* against the cuboid or scaphoid, and only the posterior part of its upper surface may remain in contact with the tibia (incomplete luxation). Or it may pass farther for- ... in this case the tibia slips behind ... luxation); the

Dislocation backwards to the upper surface of the os calcis is rare, is complete, and causes filling up of the hollows beside the tendo Achillis.

Treatment.—The complete form *cannot be reduced, and* necessitates excision of the bone. The incomplete variety may often be reduced by traction and manipulation after relaxing the muscles by flexing the knee

...rench

place-

ment may rarely be anterior, it is more often either postero-... ...al or postero-external. The scaphoid passes backwards under *the head of the* astragalus, which forms a rounded dorsal prominence; *the os calcis* also

passes backwards, but its articular surface usually still retains some contact with that of the astragalus. The heel is unduly prominent, the dorsum of the foot shortened and deformed. Inversion occurs in the postero internal and eversion in the postero-external variety.

Reduction may sometimes be secured by manipulation after relaxing muscles and dividing the tense tendo Achillis; if this fail, the astragalus may be excised. Owing to the great force required to produce dislocation the foot may be so injured that it cannot be saved.

DISLOCATION OF THE LOWER JAW

This accident may result from a blow on the chin when the mouth is wide open, or from muscular action in yawning or laughing to an exces-

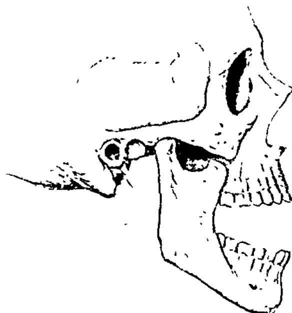


Fig. 886.—Position of bones in dislocation of jaw.

sive degree. It may also be caused by rough opening of a gag under anæsthesia, by undue downward pressure during a dental extraction, or by an attempt to take too large a bite.

In some patients with lax capsular ligaments or with indifferently developed eminentiæ articulares these dislocations are liable to recur. When the mouth is open the mandibular [illegible] move forwards on to the eminent[illegible] dislocated to a position in front of t[illegible] condyles may be displaced, as a rule, the condition is bilateral.

The patient presents himself dribbling saliva from a widely open mouth which he is unable to close. His speech is blurred, especially in the labials, and swallowing is difficult. On examination the jaw is found to be pushed forwards, the condyles can be felt in front of the eminentiæ articulares, and their normal positions are empty in front of the tragi of

the ears. In unilateral cases the signs are confined to one side and are less conspicuous.

Treatment.—The surgeon, standing in *front of the seated patient*, introduces into the mouth his thumbs, previously wrapped in thick cloth for protection. Then, pressing downwards and backwards on the last molar teeth *with his thumbs, he pulls the chin* forwards and upwards by means of his fingers placed below the mandible. (Fig. 887.) *By this* means he causes the condyles to clear the eminentiæ articulares, and the jaw is snapped back into place by the powerful muscles of mastication.



Fig. 887.—Reduction of dislocation of lower jaw by depressing the ramus and lifting the chin.

The patient should wear a four-tailed bandage for a week or ten days to prevent recurrence.

Backward dislocation is very rare, and can only occur when the tympanic ring has been fractured.

Dislocation upwards has occurred as the result of a blow on the chin, the condyle of the jaw being forced up through the glenoid fossa into the skull.

INTERNAL DERANGEMENT OF THE KNEE-JOINT

Although internal derangement may occur in other joints, it is so much commoner in the knee that it may be considered in terms of that joint. The knee is especially liable to derangement on account of its mechanical weakness relative to the important work demanded

from it. Thus it is mechanically a bad joint because enfeebled by the inward angling that normally occurs there; the weight of the body being, therefore, transmitted through a line that falls to the lateral side of the mid-point of the articulation, undue strain is thrown on the internal lateral ligament and the structures in relation with it, such as the coronary ligament and the internal semilunar cartilage. Moreover, the flatness of the articular surface of the tibia and its looseness of articulation with the condyles of the femur strongly predispose to sliding of the joint, which is only controlled by ligamentous and muscular strength and tone. The powerful crucial ligaments have an important function in this connexion; it will be remembered that the anterior crucial ligament is tense during extension of the knee, and that it prevents excessive extension; it is attached above to the posterior part of the inner aspect of the external condyle, and below to the upper aspect of the tibia in front of the tibial spine and either in front of or just mesial to the anterior cornu of the external meniscus. The posterior crucial ligament on the other hand is taut in flexion; it is attached above and in front to the anterior part of the lateral aspect of the internal condyle of the femur, and runs backwards to be inserted in the mid-line of the joint into the most posterior *part of the upper tibial surface and to the posterior surface of the* tibia for about ½ inch Rupture of a crucial ligament, therefore, produces a form of internal derangement that causes serious disability, difficult to cure.

Much of the integrity of the knee depends on the internal lateral ligament, which is attached above to the internal epicondyle of the femur, just below the adductor tubercle, and divides below into two bands, a short or posterior one that inclines slightly backwards to its insertion into the medial aspect of the tibia proximal to the groove for the semi-membranosus tendon, and a long or anterior band that passes slightly forwards to secure a long attachment to the medial surface of the tibia just below and behind the level of the tuberosity. Tears of this ligament are apt to occur either alone or in association with damage to the internal meniscus.

The synovial membrane of the knee is a complicated one with numerous folds and fringes; in some of these, notably behind and at the medial side of the patella, fibro-fatty tissue is apt to accumulate, especially in joints affected with rheumatoid arthritis and osteo-arthritis; nipping of these fringes causes a minor but troublesome derangement. Normally, freedom from nipping of synovial membrane during violent extensor movements, as in kicking, is secured by the action of the subcrureus muscle, working co-ordinately and simultaneously with the crureus and other parts of the quadriceps extensor; patients with inco-ordinate, ill-developed, or paralysed subcrureus

are therefore liable to nipping of the synovial membrane when the leg is thrown forward in walking. I have come to regard the tone and development of the quadriceps as of great prognostic importance in cases of internal derangement, for not only is this action in preventing nipping important, but the knee depends for much of its integrity and solidity not only on its ligamentous strength but on the strength, tone, and co-ordination of all the muscles playing over it; and of these the quadriceps is the most likely to go wrong.

Almost any alteration in the normal intra-articular arrangements may render the joint liable to those recurrent attacks of sudden pain, usually followed by synovial effusion, the causes of which have been grouped under the title "Internal Derangement of the Knee." Thus a crucial ligament may be torn or separated from one of its attachments and cause weakness of the joint and sliding of its component bones on one another; the internal lateral ligament may be lacerated or stretched, and may imperfectly perform its binding function; an intra-articular cartilage may be ruptured or distorted and become liable to nipping when sudden movements are made; or the offending body subjected to pressure may be a loose small fragment of bone and cartilage, separated by fracture, an osteo-arthritic osteophyte detached from its bony base and loose or swinging on a fibrous pedicle, an hypertrophied synovial villus that has become bulbous and pedunculated, a thickened or lipomatous synovial fringe, or a loose melon-seed body (rice body) composed of concentric laminæ of fibrin.

Occasionally similar symptoms may be due to trapping of a synovial fold during a sudden movement; thus, in sudden extension of the knee partly performed by the swing of the leg (as when a patient with incomplete muscular tone and co-ordination kicks forwards violently) the subcrureus fibres may fail to pull out the synovial membrane from between the bones in time. Analogous effects are sometimes seen in patients with paretic muscles and weakened internal lateral ligaments.

(a) **Laceration or dislocation of a semilunar cartilage.**—The attachments of the semilunar cartilages to the tibia are partially indicated in Fig. 888. Each semilunar cartilage ends, both anteriorly and posteriorly, in a fibrous cornu which gains insertion into the non-articular part of the upper surface of the tibia; the posterior cornu of the external meniscus also sends a fasciculus to the posterior crucial ligament. The thickened convex border of each meniscus is attached to the rim of the articular surface of the tibia by coronary ligaments; the internal semilunar cartilage is also adherent to the articular aspect of the internal lateral ligament; owing to the interposition of the popliteus and the essentially extra-capsular nature of the external lateral ligament, no such attachment

occurs in the outer border of the external semilunar cartilage. These connexions must be divided in operations for the removal of the menisci.

Lacerations and displacements of the semilunar cartilages, frequently encountered in young adults, especially athletic males, are primarily due to trauma. In flexion of the knee the menisci slide to some extent with the femoral condyles, and also rotation, which cannot occur in the extended position, becomes possible; it is some sudden movement of flexion with rotation, insufficiently governed by bracing of the muscles, that permits tearing of the menisci. During some violent

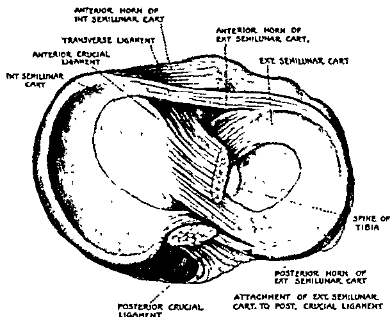


Fig. 888.—To show structures attached to upper surface of tibia.

(*After Cunningham, "Textbook of Anatomy."*)

jumping or turning movement, or as the result of stubbing the out-turned toe against a fixed object and thus throwing the whole body-weight forwards, the leg is suddenly rotated on the thigh while the knee is flexed. As a result, a semilunar cartilage, usually the internal, is injured. The primary accident may be a simple mis-step The damage to the cartilage may consist of an oblique split, frequently into its anterior end, of a partial or complete transverse tear, or of a complete separation from all anterior attachments. The detached portion may slip in and out between the joint surfaces, and therefore be liable to be frequently trapped; or it may be folded over to form a definite thickening. In old-standing cases the cartilage degenerates,

becomes friable, and may almost disappear; while the pressure of a twisted or folded semilunar cartilage may cause erosion of the articular cartilage on the femoral condyle or the upper aspect of the tibia.

Associated partial laceration of the internal lateral ligament is extremely common; it may be severe, or may merely consist of some separation of its fibres; the capsule is often torn at the same time.

Clinical features.—In the most typical cases, at the time of the primary accident the patient suffers a sudden, severe, and peculiarly nauseating pain in the knee, and may fall to the ground with the knee flexed. *On attempting to stand he cannot immediately* extend the knee or bear weight on the limb. When the internal semilunar is the one damaged, there is tenderness over the internal lateral ligament, either along the joint line or at the upper or lower attachment of the ligament. The displaced cartilage can sometimes be felt, but it is usually dislocated towards the centre rather than to the periphery of the joint.

By swinging the leg at the knee the patient sometimes snaps *the cartilage back into place; but often he cannot fully extend the* leg until the surgeon has replaced the cartilage.

A synovial effusion follows, which may entail from six to eight weeks' rest.

The onset is not always so dramatic, and definite "locking" may not be prominent. But nearly always a history of some accident can be elicited, even if it consist only of a fall on the feet, followed by local tenderness, and pain on movement or on bearing weight.

The first attack may be the last, but too often it leads to others. The weakening of the joint, especially of its internal lateral ligament, by the trauma and by the presence of the effusion predisposes to further injury, the loose cartilage may be nipped so often and so readily that the patient cannot even walk with safety. Muscular atony and atrophy occur, especially in the quadriceps extensor muscle, and, with the ligamentous laxity, permit undue lateral mobility of the joint.

After damage to the internal meniscus, a point of tenderness often persists at a point just above the upper margin of the tibia and about halfway between the inner margin of the ligamentum patellæ and the internal tuberosity of the tibia.

Prognosis.—Careful treatment may prevent recurrences, but the victim of one displacement is very liable to others. *Neglect of a* distorted cartilage leads to permanent weakness.

Treatment.—If reduction has not already resulted from the patient's efforts, the surgeon replaces the cartilage by fully flexing the knee, rotating the leg so as to open up the joint line, pressing

over the injured cartilage, and then suddenly extending the knee and rotating the leg inwards. An anæsthetic is sometimes necessary.

Then rest should be commanded and the synovial effusion treated. Superficial and soothing massage (light effleurage) should be commenced at once; later, when effusion and tenderness have gone, deeper pétrissage and passive movements should be added. Special attention should be given to the quadriceps muscle.

The subsequent liability to recurrence should be met by raising the boot on the inner side so as to throw the foot outwards, by teaching the patient to walk with the toes directed straight forwards or a little inwards, and perhaps by causing him to wear a knee-truss which, though permitting pure flexion and extension, allows no rotation or lateral movement. Even if the cartilage has slipped out more than once, success may follow immobilization or the use of a knee-truss.

Usually, however, repetition of the attacks calls for operation, especially in a patient of such occupation that an unexpected fall would be dangerous. If this method be not postponed so long that the articular cartilages are involved and the muscles and ligaments permanently weakened, the results are usually excellent. The condition of the quadriceps is particularly of prognostic importance; steps should be taken, before operation, to maintain and, after operation, to restore its tone and nutrition. A tourniquet is applied to the thigh and the leg is caused to dangle over the end of the table, the foot being grasped between the operator's knees; in this manner the operation is done bloodlessly and, as the surgeon can manipulate the limb by movements of his knees, he can work single-handed; the tourniquet is finally removed after the wound has been dressed with a thick and elastic layer of cotton-wool, fixed with a firm bandage. A longitudinal or slightly semilunar incision is made on the inner or outer side of the patella, as the occasion demands, and the joint opened, with care to preserve the integrity of the lateral ligaments; then the whole of the offending cartilage is removed. Attempts at repair by suture are troublesome and generally fail. In all cases the lateral ligaments, especially the internal, should be examined and any rents or weak parts sutured. Often the subsynovial pad near the edge of ligamentum alaria is seen to be juicy and thickened, or sometimes fibro-adipose; it is then my custom, when suturing the incision through the synovial membrane, to include this projecting pad in one or two sutures, to fix it, and to prevent it from flapping or becoming nipped and so reproducing the symptoms of internal derangement. After the joint has been closed, rest should be enjoined for two weeks; massage should be gently commenced in a few days, and passive movements begun after five days; skin sutures may be

removed on the fifth day and continued coaptation secured and protected by the use of a few narrow strips of adhesive strapping applied across the wound; if this be not done, the passive movements may cause slight superficial gaping of the wound. Flexion to a right angle should be easy by the twelfth day, and the patient may get about with support on the fourteenth day. If, however, much effusion has followed the operation, these periods will be lengthened.

(*b*) **Loose bodies in joints.**—A loose body may be either quite free or pedunculated, and may consist of any of the structures enumerated above. It causes constant irritation; from time to time it becomes entrapped, the joint locks in a flexed position, and the patient suffers sudden pain, which may be acute and sickening. A synovial effusion follows, and may persist more or less chronically in the intervals between attacks.

A loose body may sometimes be felt, or, if bony, it may be seen with the X-rays. A loose body largely composed of cartilage can continue its growth even when quite detached in the joint cavity; it is apparently capable of obtaining nourishment from the synovial fluid

Treatment. — The joint should be opened and the loose body removed A prolonged search in the corners of the joint may be necessary. In some cases the patient, by frequent practice, can manœuvre the slippery body to the edge of the joint, where it can be felt, in such a case it should be transfixed with a needle through the sterilized skin, the patient then anæsthetized, and the joint opened. Before closing the joint the surgeon should determine the absence of other abnormal bodies He then closes the capsular opening with catgut sutures, and the skin wound with Michel's clamps. Massage and passive movements may be begun in two or three weeks.

In many cases a wide view of the joint cavity is necessary; in the knee-joint, the one most likely to contain a loose body, this freedom of access is not readily obtained by any small incision. To secure a good view Robert Jones splits the patella, the quadriceps, and the ligamentum patellæ longitudinally; retraction then exposes the joint cavity freely. Timbrell Fisher suggests that the resultant injury to the patella may initiate osteo-arthritic changes (Fig. 889), and, instead, after making a flap-like skin incision, splits quadriceps and ligamentum patellæ medially but avoids splitting the patella; here he dissects to one side the fascia over that bone to a point ½ in. beyond its edge, then, by opening the capsule and dislocating the patella, he obtains an excellent exposure without material damage to patella or quadriceps.

Lipoma arborescens may cause similar, though less acute symptoms. It may be excised and the joint closed.

The **prognosis** of lipoma arborescens, as of loose bodies, is usually less favourable than that of dislocated internal semilunar cartilage, for in many cases the condition is associated with some underlying disease, such as osteo-arthritis, rheumatoid arthritis, etc

Rupture of crucial ligaments results from great violence; it may be associated with fracture of the tibial spine. Pain and effusion of blood are great; movements are abnormally free; partial luxation backwards or laterally may be possible; if the anterior crucial ligament is torn, forward movement of the tibia can be obtained even when the knee is extended, when the posterior one is lacerated, backward movement of the tibia can be made with the knee flexed. Neither of these movements would be possible if the crucial ligaments were intact.

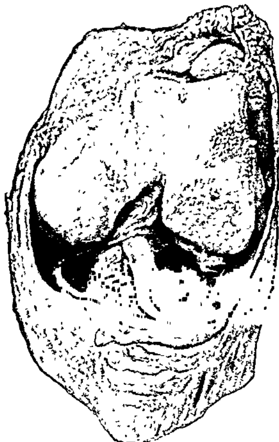


Fig. 889.—Osteo-arthritis and fracture dislocation of external semilunar cartilage; a loose body of the classical type is also present in upper part of joint. (709 A *Middlesex Hospital Museum*)

(*"British Journal of Surgery"*)

Treatment.—The condition calls for very prolonged rest, at first in bed with the limb on a back splint, later with the use of an apparatus to secure immobility of the knee. Suture has been done, but it is difficult at operation to suture taut, and failure often follows. Hey Groves, in very chronic cases, has brought tendinous material through holes drilled in the femur and tibia in such position as to make the new substituted ligament run in the same line as the original ligament; for the anterior crucial ligament he substitutes a strip of ilio-tibial band, for the posterior he uses semitendinosus tendon. If the

tibial spine has been detached and is getting into awkward positions, free exposure of the joint cavity by Robert Jones's patella-splitting method or by Timbrell Fisher's incision is necessary; the spine may then be affixed or removed and a reconstitution of crucial ligament by suture or by Hey Groves's substitution method adopted.

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ORTHOPÆDIC SURGERY

By W. H. TRETHOWAN, M.B., B.S., F.R.C.S.

GENERAL CONSIDERATIONS

The origin of deformity.—Orthopædic surgery deals with gross structural abnormalities in the skeletal or the neuro-muscular system—whether potential or existing and, perhaps, increasing—that cause corresponding physical and mechanical disabilities; it aims at correction of anatomical faults and restoration of function, especially in the locomotor apparatus. It is also concerned with prophylaxis, because many deformities can be avoided by simple measures, and because, complete anatomical restoration being oftentimes impossible, occurrence or recurrence of deformity is inevitable, unless prevented Primary defects beget secondary deformities in response to altered physical and anatomical conditions.

Deformities are congenital or acquired. *Acquired* deformities form five groups: (1) *paralytic*, e g. due to anterior poliomyelitis or to cerebral disease; (2) *static, mechanical, or postural*, resulting not from obvious disease but from inefficient response to ordinary physical forces, as in flat-foot and most cases of scoliosis; (3) *arthritic*, secondary to joint disease, e g. rheumatoid arthritis or tuberculosis; (4) secondary to *osseous* disease, such as rickets or tuberculous spondylitis; (5) *traumatic*, e g. malunion and non-union of fractures, and scarring following injury of the soft parts. Whatever the initial cause or original pathology of the deformity, static or mechanical factors are always important accessories in its development The limbs act as levers, usually of the third order, the bones being the levers, the joints the fulcrums, and the muscles supply the power. For perfect function, therefore, the mechanical conditions necessary are normal bones, stable and movable joints, and vigorous muscles In man must be added the psychic factor of the will to make the mechanical effort, and the various purely sensory mechanisms.

Besides the external work done, muscular effort is constantly expended merely to preserve balance and prevent improper posture. Attitudes of muscular activity regularly alternate with those of rest; in the former the strain is taken principally by the muscles, while in

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GENERAL CONSIDERATIONS

The origin of deformity.—Orthopædic surgery deals with gross structural abnormalities in the skeletal or the neuro-muscular system—whether potential or existing and, perhaps, increasing—that cause corresponding physical and mechanical disabilities; it aims at correction of anatomical faults and restoration of function, especially in the locomotor apparatus. It is also concerned with prophylaxis, because many deformities can be avoided by simple measures, and because, complete anatomical restoration being oftentimes impossible, occurrence or recurrence of deformity is inevitable, unless prevented. Primary defects beget secondary deformities in response to altered physical and anatomical conditions.

Deformities are congenital or acquired. *Acquired* deformities form five groups: (1) *paralytic*, e.g. due to anterior poliomyelitis or to cerebral disease; (2) *static, mechanical, or postural*, resulting not from obvious disease but from inefficient response to ordinary physical forces, as in flat-foot and most cases of scoliosis; (3) *arthritic*, secondary to joint disease, e g rheumatoid arthritis or tuberculosis; (4) secondary to *osseous* disease, such as rickets or tuberculous spondylitis; (5) *traumatic*, e.g malunion and non-union of fractures, and scarring following injury of the soft parts. Whatever the initial cause or original pathology of the deformity, static or mechanical factors are always important accessories in its development. The limbs act as levers, *usually of the third order, the bones being the levers, the joints the fulcrums*, and the muscles supply the power. For perfect function, therefore, the mechanical conditions necessary are normal bones, stable and movable joints, and vigorous muscles. In man must be added the psychic factor of the will to make the mechanical effort, and the various purely sensory mechanisms.

Besides the external work done, muscular effort is constantly expended merely to preserve balance and prevent improper posture. Attitudes of muscular activity regularly alternate with those of rest; in the former the strain is taken principally by the muscles, while in

the latter it falls mainly on the ligaments. But "locking" of joints, as in hyperextension of the hip and knee, and in abduction of the foot when the body is standing easy, does not abolish although it minimizes muscular effort, for the postural reflexes of the anti-gravity muscles, shown by their normal tonus, also assist in preventing collapse of the body under the influence of weight. *Body-weight* is therefore one of the most important agents in the production or increase of deformity. Its effect is seen not only in the standing posture, but also in the sitting, as in the production of spinal curves. Even when the body is recumbent, gravity may produce deformity, as in dropped foot, or in kyphosis in spinal caries. Disturbance of *muscle-balance* about a joint is another cause of deformity. This balance of antagonistic muscles depends not so much on muscle bulk as on the usual and normal functions; thus the extensors of the ankle are much stronger than the flexors because they do greater work in locomotion. Paralysis or weakening or overstretching of a muscle group allows the healthy antagonistic group to induce improper positions, which, unless corrected, will persist; the tissues on the paralysed aspect become atrophied, weak, and lengthened, while those on the overacting side contract. Excessive muscle spasm, e.g. in acute joint affections and in cerebral paralyses, may also effect the disturbance of muscle-balance. Yet another cause of deformity is habitual improper *posture*, depending on various and often slight causes: the posture of rest is adopted, in which strain is taken by the less fatigable bones and ligaments, unless alternated with periods of muscular activity, the attitude of rest becomes a fixed bad posture, incapable of voluntary correction. Thus in scoliosis the initial faulty curve, if unchecked, becomes rigid; later the incorrect balance and direction of weight-bearing gradually increase the deformity.

In the pathology of deformities must be considered: (1) the *cause;* (2) the *primary deformity,* due to gravity, posture, and abnormal muscle-balance; (3) the *secondary deformities* in neighbouring joints, in response to efforts at compensation; (4) *accommodative* or *adaptive changes* in the structures involved in the primary and secondary deformities, following attempts at function exercised by the distorted parts.

Potential deformity must be anticipated, and prophylactic measures taken The hump of spinal caries, the flexion contracture of the arthritic knee, and the dropped foot after neuritis, result from lack of precaution. If only incomplete recovery of joint lesions can be expected, with partial or complete ankylosis, care must be taken that the ultimate fixed position of the joint is such as will be of most service. A hip should be fixed at 30° of flexion, and in very slight abduction, a compromise between the most useful positions for sitting and standing, and causing the least ill effect on the pelvis and spine. An adult stiff

knee should be flexed 10°, a juvenile knee hyperextended; and a stiff foot fixed in such position that, when the boot is being worn, it is at a right angle with the leg and slightly abducted.

Uncorrected primary deformity is invariably followed by *secondary deformities* in neighbouring parts. Nature tends to neutralize a single curve by producing a double or even treble curve. A flexed hip increases the normal lumbar concavity; an adducted hip produces a tilted pelvis and spinal curvature. A flexed knee will give rise to a dropped foot and a flexed hip, and to shortening of the leg which will cause pelvic tilting and spinal curvature. The production of the secondary deformity is thus often the "natural cure" In rickety legs, when the active process is over, as many as seven or eight curves may exist. The point is of importance in treatment, as the secondary deformity may be the more disabling; and indiscreet correction of the primary deformity may uncover and exaggerate an otherwise harmless secondary distortion.

Accommodative changes result from altered stresses, and from non-use or improper function of displaced parts This adaptation occurs first in the soft parts, and only more slowly involves the bones; it is a gradual process, and continues throughout life. The bones alter in external shape and internal structure in response to changed function, as postulated by Wolff's law. Sometimes certain deformities, such as scoliosis, flat-foot, etc, are grouped into clinical stages. When the part is pliable and the deformity capable of voluntary or of passive correction, it is assumed that practically only soft tissues are involved, and the terms habitual, postural, functional, non-rigid, or "first-stage" are applied. If passive correction is impossible, the deformity has reached the late, "second," structural, fixed, or rigid stage But in the underlying changes there is no sharp line corresponding to this clinical distinction; the structural changes are gradual; the osseous alterations especially are slow, and form the strongest obstacles to correction. Examples of accommodative changes are seen in the osteophytic buttresses on the apices of the wedge-shaped vertebræ in intractable scoliosis; in the "traumatic" arthritis supervening in the knee- and the ankle-joint on improper function in the case of a malunited femur or tibia; in the alteration of the shape of the tarsal bones in inveterate club-foot; in the contracture of unparalysed muscles and tendons in paralytic legs; and in the changes in the unused acetabulum and femoral head in unreduced congenital dislocation of the hip.

Treatment of deformity.—A general survey of the principles of treatment will save repetition later Most deformities develop insidiously. The chief indication is **anatomical correction** sufficient to secure the maximum usefulness compatible with

the defective conditions. Well-developed deformity involves all the tissues of the part, only some of which can be shortened or lengthened by operation; many distortions cannot be *rectified by a single operation* The tissues, too, vary in their tolerance of operative interference: bones are very amenable, and ligaments and fasciæ permit free incision with certainty of healing at the desired length: articular cartilage is the most intolerant of the connective tissues; preservation of joint surfaces is vital for restoration of movement. Tendons will heal quickly and satisfactorily if the gap be not excessive and the sheath be *preserved. Often the tendons are not so potent in fixing* deformities as is generally imagined, the ligaments being far more resistant to passive correction. Muscles may be transplanted bodily, as far as their vascular and nervous conditions permit, but suture of muscle substance gives a poor functional result. The danger of damaging contracted vessels and nerves by stretching often hinders correction; contracted skin is generally only amenable to plastic methods. *Therefore in operations for deformity only some structures may be divided;* others must be gradually stretched; and some deformities, e g. scoliosis, occur in parts unsuited to operation.

In *gradual correction* passive stretchings of contracted tissues are repeated (usually daily), assisted by stimulation of weakened, lengthened antagonistic muscles to attempt active correction; at the same time, general mobility must be preserved by passive movements *in all directions. Usually a removable splint is also employed to* maintain the passive stretching day and night. This method is rational, for by massage and early active exercises it preserves muscular nutrition and articular mobility while the passive correction is proceeding; but it is slow and laborious. When quicker results are desired or daily skilled treatment is unavailable, *forcible correction* is to be used. Usually under anæsthesia, *wrenching* is done, either *by* strong manual correction or *by instrumental means.* The maximum available correction is obtained at one sitting and the part splinted (usually in plaster of paris) for one to three weeks, in the best position obtainable; the splint is only removed when probably the soft tissues are relaxed enough to allow further correction by a second wrenching and plaster. The process is repeated until the deformity is just over-corrected. The manipulation may be facilitated *by subcutaneous division of resistant fasciæ* and tendons. *Overcorrection* allows for any residual resiliency in the contracted tissues. Forcible correction is quicker than gradual daily manipulation, and devolves more on the surgeon; but it also may be slow and laborious, and it has the disadvantage that restoration of function *is not concurrent* with correction of deformity, so that wasting becomes extreme, joints are unnecessarily stiffened, and return of function is slow.

Quicker is the method of *open operation*, whereby all ligaments and fasciæ are freely divided, tendons lengthened or transplanted, and the deformity is almost corrected at one sitting. Subsequently, fixation in plaster or a splint for two or three weeks will complete the correction while the wound is healing; and functional use is entered upon immediately after the first stage. This method has the advantage over that of subcutaneous tenotomy and wrenching, in that the tightened tissues can actually be determined. Generally ligaments resist correction more than tendons; they are not easy to define and cut subcutaneously, and by forcible manual wrenching they are often torn from their bony attachments rather than stretched or ruptured as desired. The inflammatory reaction and stiffness after wrenching are due to this cause. In many cases, especially those of long duration involving structural alteration of the bones, correction by one of the above measures will apparently quickly correct the faults in the soft tissues, but the bones adapt themselves much more slowly; therefore the protective and corrective action of incomplete functional use in splints must be continued while skeletal adaptation is occurring. Incomplete adaptation of the skeleton to full efforts at function is one cause of relapse; hence, while waiting for complete adaptation to develop, the patient is allowed to use the part in a limited and protected way, getting about in splints or plaster. This *corrective effect of function* is well recognized in practice. The choice between removable splints or plaster of paris depends on the exigencies of the case and on the surgeon's predilection. Appliances can be removed for daily physico-therapy, but require continual skilled supervision; whereas plaster, while more effectually fixing the part, causes difficulty in the application of massage and movements.

The remedial measures for the restoration of function are begun either during or immediately after the correction of the deformity.

Re-education and restoration of function.—The chief and most rational restorative is the use of the limb, as far as is possible, in its normal physiological way. Rest and recumbency must cease as soon as the inflammatory process is sufficiently quiescent. A patient suffering from poliomyelitis will not obtain the greatest efficiency of his muscles until he is compelled to get about. Physiological use is essentially *active exercise* of an interesting, useful, or productive kind. The function may need to be modified, or protected, or assisted in various ways, as in preventing fatigue of weakened muscles, and when splints and appliances are required to negative the deforming effect of relatively stronger antagonist groups. The ordinary muscular actions of life may be too strenuous at first, and only simple exercises should be given to the separate

muscle groups against the carefully graduated resistance of a remedial gymnast. *Passive exercise*—forced movement applied by an external agent, with or without anæsthesia—serves to stretch contracted tissues and adhesions. Whilst active exercises can rarely be harmful, passive movements must be employed with discretion, for tissues may be torn, inflammatory reaction set up, and inflamed synovial membranes bruised. *Massage* is a preliminary to the various movements, serving to remove the thickening and induration following inflammation and traumatism (frictions), and to assist the circulation and stimulate local nutrition (pétrissage, effleurage, tapotement). The local application of *heat* before the exercises and massage helps to soften the tissues and to promote local hyperæmia. For muscles with intact nerve supply but in which voluntary effort is weak, and for conditions where normal active movements are contra-indicated, *faradic* stimulation, producing an imitation of normal contraction and relaxation but never a fatiguing tetanization (the method of "graduated contraction"), is an important restorative measure. When the nerve supply is damaged, voluntary power lost, and faradic response absent, *galvanic* contractions help to preserve muscle tissue.

Physico-therapeutic measures must *always* be supplemented by the personal efforts of the patient.

Recurrence results either from persistence of abnormal effects of gravity when unchecked by the restraining influence of some retentive splint or appliance, or from the use of the part under unbalanced muscle conditions; the latter may be due to defective muscles, or to inco-ordinated muscular actions. Complete re-education of function therefore requires full attention. Many orthopædic operations are designed primarily to improve function rather than structure. Some, such as *tendon and muscle transplantations*, are intended to restore muscle-balance where certain muscles are paralysed; others, such as artificial ankylosis (*arthrodesis*), stabilize a joint uncontrollable and flail from destruction of its activating muscles, or one that is inadequate and painful. Paralytic flail-joints cannot voluntarily be fixed, and the power remaining may be insufficient for advantageous redistribution by tendon transplantation. Sometimes the artificial fixation of the uncontrolled joint is effected by converting the tendons of the paralysed muscles into ligaments (*tenodesis*). In other cases, e.g. spastic paralyses, the balance of power is obtained by weakening the overactive muscles, either by *tenotomy* or by partial resection of their motor nerve supply (*neurectomy*). Again, operations such as spinal bone-grafting or fixation (*fusion*) prevent recurrence of deformity, either by acting as internal splints to counteract the effect of gravity, as in spinal caries, or by ankylosing joints which

would become deformed from permanently unbalanced muscular control, as in paralytic scoliosis.

Appliances.—Appliances are frequently used as an alternative treatment to open operations primarily directed to the restoration of

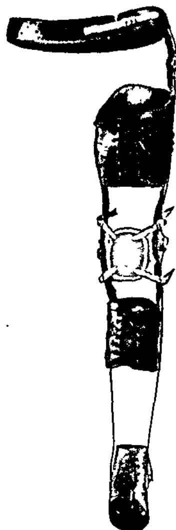


Fig. 890.—Ambulatory weight-relieving apparatus for hip. (*Ernst, "Orthopædic Apparatus."*)

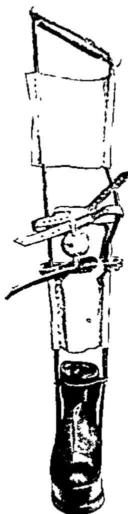


Fig. 891.—Calliper splint, with cork-soled boot.

function or the prevention of relapse of deformity. The simpler and the lighter they are, the better. Open or skeleton splints and appliances are preferable to closed casings such as leather and celluloid, because they afford ventilation, less constriction, better access, and

greater adaptability to growth. The simpler splints merely rest an inflamed or injured joint, or keep paretic muscles relaxed and shortened, e g. the Thomas hip-splint, the "cock-up" splint, and the shoulder abduction splint. Appliances may be—(1) *corrective*—a means of gradually reducing deformity, as the Scarpa shoe for club-foot (a corrective splint is, in a sense, a passive exercise); (2) *retentive*—to prevent recurrence of deformity otherwise corrected, while the adaptive changes and recovery of function are slowly taking place, or to act as a substitute treatment for transplantation and arthrodesing operations, e.g. leg irons, the spinal instrument for scoliosis and caries, and side steels used for paralytic feet; to avoid the permanent use of appliances is one of the aims of orthopædic surgery; (3) *restrictive*—to restrain excessive movements of joints, keeping them within the harmless and unirritating range, e.g. the "knee-cage" for arthritis and inoperable derangements of the knee-joint; (4) *weight-relieving*—as in the calliper modification of the Thomas knee-splint (Fig 891), which is useful in the later treatment of all those conditions of injury and disease of the hip-joint and leg in which modified function is permitted but transmission of weight harmful. A more elaborate splint of the same type is that of Hessing (Fig. 890). The calliper splint is frequently used also as a cheap and effective splint to support a knee and ankle which, uncontrolled by muscles, would collapse in the effort of weight-bearing. Used thus, its length is so arranged that weight-bearing is permitted through the limb itself.

CLUB-HAND

Club-hand, or congenital deformity at the wrist, is rare. In a great majority of cases there is either a congenital deficiency or a complete absence of one of the bones of the forearm, usually the radius. When this bone is absent some of the carpus may also be deficient, and the thumb may be

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Treatment.—When there is no bone deficiency, a good result can be obtained by repeated manipulations and the maintenance of the hand in the over-corrected position by a simple apparatus or by plaster of paris. When there is osseous defect, the deformity must be corrected by manipulations, and the correction then maintained either by a permanent appliance or by some open operation such as bone-grafting. The balance may be restored by removing a piece from and re-aligning the ulna, when the

latter is too long and curved, or the ulna may be split longitudinally for a few inches and the carpus impacted into the cleft. Another operation, to make the ulna Y-shaped, is to graft a piece of tibia into the ulna about 3 or 4 in. above its lower end, the other extremity of the graft being impacted into the radial side of the carpus.

DEFORMITIES OF THE FEET: DEFINITIONS

Deformities of the feet are congenital or acquired; of the latter, the majority are of paralytic or of mechanical origin, only a few being due to other causes, such as arthritis and injury.

The term *talipes* (*talus-pes*), originally signifying the commonest form of congenital deformity, equino-varus, is now applied generally to most pedal deformities. The deformity is often very complicated, and made up of several of the following simpler distortions.

T. equinus (dropped foot).—The foot is plantar-flexed, the heel cannot reach the ground, and the weight is borne on the balls of the toes. Usually the deformity occurs at the ankle-joint, but sometimes the drop occurs at the transverse midtarsal joint, so that only the forefoot is involved; the latter deformity is really one variety of *cavus*.

T. calcaneus (heel foot).—The heel is depressed and takes all the weight. The whole foot may be dorsiflexed at the ankle (congenital cases), or the backfoot alone may be dorsiflexed while the forefoot is dropped at the midtarsal joint (acquired cases, *calcaneo-cavus*).

T. varus.—The whole foot is tilted inwards at the subastragaloid and mid-tarsal joints—inverted or supinated, and the weight is borne on the outer border. With this the forefoot may be further adducted at the midtarsal joint, the front and back portions of the foot forming an angle with each other convex outwards. Sometimes only inversion of the forefoot exists (*metatarsus varus*).

T. valgus (weak ankle).—The foot is everted or pronated, weight tending to fall on the inner side. The forefoot may or may not be everted on the backfoot.

Pes cavus (hollow or "claw" foot, high arch).—The height of the long arch is increased abnormally, from depression of the heel, of the toes, or of both.

Pes planus (flat-foot).—The long arch of the foot is obliterated, and the forefoot abducted.

CONGENITAL TALIPES (CLUB-FOOT)

Of the congenital deformities of the foot, talipes equino-varus (Fig. 892) is by far the most common; talipes calcaneo-valgus is the only other common congenital form.

Talipes Equino-Varus

Etiology.—The cause is unknown, but is generally supposed to be malposition in utero. Heredity is only rarely a factor. In the fœtal attitude in utero the hips and knees are fully flexed and adducted and the feet, especially if short, fall into the equino-varus position, one over the other.

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constrictions may limit the natural movements of the feet and keep them in malposition during their development. This may lead to overstretching and lengthening of some leg muscles—*e.g.* in talipes equino-varus the anterior and peroneal muscles, in talipes calcaneo-valgus the posterior muscles. Deformity, or even amputation, may rarely result from constriction of the leg by the umbilical cord. Occasionally some of the bones of leg or foot may be congenitally absent. There may be associated deformities elsewhere, such as hare-lip or ectopia vesicæ.

Pathological anatomy.—It is convenient to consider the foot as divided at *the midtarsal joint into forefoot and backfoot.* In congenital club-foot an element of deformity exists in each of the three main joints. Equinus occurs at the ankle, varus or inversion at the subastragaloid and midtarsal joints, and adduction of the forefoot at the midtarsal joint. There may also be adduction of the posterior half of the foot (astragalus and os calcis), due to the rotation of the os calcis on a vertical axis beneath the astragalus, the distance from *external malleolus to heel being lessened.* The degree of the elementary deformity at any one joint may vary in different cases; when the varus is corrected the equinus is more noticeable. Bones as well as the soft parts are deformed, and the degree of abnormal shape will depend on the age of the patient and the extent to which function has been permitted in the uncorrected foot. In the infant club-foot the heel is small and round, drawn up, inverted, and nearer the external malleolus The posterior half of the foot is rotated on an antero-posterior axis so that the sole looks inwards, and may at times be adducted relatively to the leg. The forefoot is inverted with the backfoot, and adducted relatively to the backfoot at the midtarsal joint, its inner border being raised and *directed towards the tibia. The adduction* of the forefoot may be extreme, with actual dislocation at the midtarsal joint, a vertical crease appearing on the inner border. The ligaments and other soft tissues on the outer and dorsal aspects of the foot are lengthened, and those on the inner and plantar aspect shortened. The posterior tibial muscles and tendons are shortened, and the long extensors of the toes and the peroneal group are overstretched and weakened. In older cases, *especially* when the foot has been used in a deformed position, the changes in the shape of the bones themselves are more obvious. These involve principally the astragalus and the os calcis. The os calcis is lengthened in its outer border, its fore-end depressed and turned slightly inwards, and the inner tuberosity raised and turned *inwards. The whole bone is* ... vertical ... l dimin- ... ts outer aspect, and its neck twisted downwards and inwards. ... *osity of* the scaphoid lies near the inner malleolus, on the inner and under *side of* the head of the astragalus, ... of the ... on foot. The *front* end of the ... the outer side of the foot.



Fig. 892.—Congenital talipes equino-varus.

Of the contracted ligaments, the most important, from the difficulties they afford in treatment, are those on the inner side of the foot and at the back of the ankle-joint. The inferior calcaneo-navicular and deltoid ligaments, together with the insertion of the tibialis posticus tendon, form a dense mass of fibrous tissue, perhaps $\frac{1}{2}$ to $\frac{3}{4}$ in. thick, fixing the inner end of the scaphoid to the os calcis and internal malleolus. This is known as the calcaneo-scaphoid capsule, and is such an obstacle to the correction of the adducted forefoot and the inverted backfoot that its complete excision may be necessary. Similarly, the posterior and inner ligaments of the ankle-joint are, from their density and contracture, the chief obstacles to relief of the equinus and varus of the backfoot. In inveterate cases the cuboid and fifth metatarsal become thickened from weight-bearing pressure on the outer border, or even the dorsum of the foot, with superficial bursa-formation, and perhaps corns and bunions. Knock-knee may develop. Only very rarely is the turning in of the toes in walking due to an inward twist on the tibia or femur. Accommodative changes occur in the articular cartilages of the tarsal joints, and the bad shape of the bones and soft parts gradually becomes exaggerated. The disability varies with the degree of deformity. Walking is delayed in infantile cases, and considerable pain and lameness result in later life if the deformity is uncorrected.

The production of the congenital equino-varus deformity will more easily be understood if we remember what happens in the development of the normal foot. In the fœtus the foot is persistently inverted up to the seventh month, and this inversion may, even normally, exist at birth or for some months later. According to Keith, the inversion of the foot becomes corrected in the following manner: (1) The neck of the astragalus, which in the fœtal foot is long and directed downwards and inwards at an angle with the axis of the body of the bone (35° in the fœtus, as compared with 10–12° in the adult), becomes relatively shorter and directed more in line with the axis of the superior articular surface; further, the outer border of the tibial articular surface of the astragalus is prominent, while the inner border is much lower, and a growth upwards of the inner border causes the astragalus and the foot to abduct or rotate outwards (Lazarus). (2) The bones on the inner side of the foot, especially the scaphoid and internal cuneiform, grow more rapidly, especially after birth, than those of the outer side, this tends to evert the foot and also to produce the longitudinal arch. (3) A special evertor of the foot is developed, the peroneus tertius, a muscle peculiar to man.

If, as in congenital club-foot, the scaphoid is dislocated or subluxated from its normal articulation with the head of the astragalus, it will not develop nor remain associated with the head and neck of the astragalus when the latter straightens and thickens during the normal process of the eversion of the foot. Thus will occur the commonest type of equino-varus, in which the scaphoid is found near or in contact with the internal malleolus, and lying to the inner side of the head of the astragalus, which itself forms a

the base outwards. To the apex, representing the tubercle, is attached the tibialis posticus tendon, the latter being found partly between the head of

The former or inward dislocation of the scaphoid is by far the more common; *clinically*, the head of the astragalus can be felt projecting on the dorsum of the foot. Maldevelopment and outward dislocation of the scaphoid is much more rare, but undoubtedly occurs. It happens occasionally that failure of development of the inner border of the foot may be due solely to the internal cuneiform. This is the cause of some cases of metatarsus varus (Bankart), in which the congenital deformity—adduction of the metatarsus and toes—involves the forefoot only.

According to the above view, equino-varus is essentially *a congenital dislocation occurring* at the inner part of the midtarsal joint, and presenting various degrees of subluxation. The subluxation actually existing may at first be very slight, the deformity becoming gradually exaggerated by the effects *of irregular* growth and ill-balanced muscular action, and later by the further influence of improper *weight-bearing. The co-existent deformity in* the outer part of the midtarsal, and in the subastragaloid and ankle-joints, is thus secondary to the primary dislocation or subluxation


Fig. 893.—Severe talipes equino-varus.

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paralysis by less wasting, and absence of circulatory changes. The *congenitally* deformed foot is not flail in some or all movements, as in infantile paralysis, and voluntary or *faradic response can usually* be elicited. Shortening of the limb is commonly far greater in paralytic than in congenital club-foot. In the congenital type the varus is always worse than the equinus, whereas in paralytic cases the equinus is usually worse than the varus. The congenital deformity more constantly resembles that *seen in cerebral paralyses*, but the latter is distinguished by the increased reflexes, the spasticity of the whole limb, and the characteristic gait. (Fig. 893)

Treatment.—Treatment must be begun as soon as possible after birth, the aim being to have all elements of the deformity completely corrected *by the time a normal child would begin to walk*, as *weight-bearing* and walking are the chief factors in maintaining the correction and stimulating the return of muscular balance and function. If treatment is begun early, when the tissues are *soft and pliable*, a large *proportion of the cases* can be completely cured by the combination of splintage and manipulations; neither alone will suffice.

Manipulations.—The first aim is *correction of the adducted forefoot* and the inverted whole foot, the varus, which can usually be accomplished in two or three months. Thereafter attention is particularly directed to

of the thumb fixes the centre of the outer side of the foot. The fingers of the other hand grasp the forefoot just behind the toes in a dorso-plantar grip, and thus heel and forefoot are stretched outwards. Another grip used is that with the thumbs on the outer border of the foot and the fingers on the inner sides of the heel and metatarsus. The stretching must be done firmly and vigorously, at least twice daily for ten or fifteen minutes, and the deformity must be overcorrected. The foot must be made so supple that it can finally be placed as easily in the overcorrected as in the deformed position. Attention must be concentrated upon the adduction and inversion of the forefoot on the backfoot, and upon the adduction and inversion at the sub-astragaloid joint and the turned-in heel. Day and night the varus must be held as corrected as possible by a padded splint of malleable metal, about 1 in. wide, extending from above the knee to just beyond the toes, and bandaged on the outer side of the leg and foot. As the foot becomes more supple and the correction more extensive, the splint can be bent so as to present a convexity towards the leg, until finally the foot is easily held in the overcorrected or valgus position.

Next the equinus is attacked, and manipulations directed to bringing down the heel and stretching the tendo Achillis and posterior capsule of the ankle joint. The manipulations for varus are continued meanwhile, but, in addition, the foot is strongly thrust upwards in dorsiflexion As the high fixed heel (equinus) is an advantage in the initial correction of the varus, on no account must a tenotomy of the tendo Achillis be contemplated before the varus and adduction are completely corrected. For the equinus a different splint is required, which will maintain valgus as well as dorsiflexion. The best is a modification of the "club-foot shoe" A hollow trough (aluminium) half encircles the leg from the knee to 1 in. above the ankle,

dorsiflexion of the foot. A padded strap across the front of the ankle, passing to a stud at the back of the footpiece, holds the heel down and maintains the correction of the equinus. A T-strap on the outer side of the footpiece holds the ankle well in to the connecting side steel. Valgus is maintained by the flange and the T-strap. The whole splint and leg is then firmly bandaged from top to bottom. If more eversion of the foot is necessary, a thigh-trough can be attached, so that the knee is flexed to a right angle. All manipulations should be preceded and followed by a few minutes' massage of the leg and foot, but it must be remembered that mere rubbing cannot take the place of the vitally important passive stretchings As the correction proceeds, all splints may be omitted for an hour or two each day, to encourage active movements and assist circulation.

An alternative method of treatment, especially in hospital practice, where at times the daily manipulations and application of splints are not properly carried out by the parents, is that of repeated forcible correction under anæsthetic, with immediate fixation in the overcorrected position in plaster of paris As before, the inversion and adduction are corrected first, and the equinus subsequently. Some surgeons prefer to include the knee

and thigh in the plaster, the knee being flexed to a right angle, with the object of better controlling the valgus and external rotation and of preventing the plaster from slipping off. The plaster must not be applied too tightly, otherwise pressure atrophy occurs and growth is retarded; for the same reason it must be renewed at intervals of not more than one month. At times the correction is hastened by tenotomy (*see* below) in addition to the wrenching The plaster stage may continue until full correction is attained, being then followed by manipulations, massage and splints, or by walking appliances. When the knees are not included the child may be allowed to walk in plaster in the later stages of correction.

Operative treatment.—*Subcutaneous tenotomy* is often done to assist correction by manipulations and splints. To correct the varus, the tendons of the tibialis anticus and posticus have been divided at the level of the base of the malleolus, and for the equinus the Achilles tendon. In the past, tenotomies have been much too freely used and have eventually led to considerable impairment of function. The tendon scar may stretch or adhesions may form Certainly the tibiales anticus and posticus tendons rarely need division; if necessary, it is better to open the foot on the inner side, and divide the ligaments and completely excise the calcaneo-scaphoid capsule.

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at the same time as the tendon. Tenotomy must in all cases be followed by daily manipulations and splints, or by fixation in plaster of paris, as described above.

After the third or fourth year of age, in untreated, neglected, or relapsed cases, or in those with some varus of the whole foot or adduction of the forefoot persisting in spite of regular manipulation and splinting, *open operation* is required. Such operation should avoid damage to the articular cartilages, removal of whole tarsal bones, resection of bony wedges, or osteotomies that damage joints; but ligaments may be freely divided. Residual adduction of the forefoot is due to a dislocation inwards at the midtarsal joint, and must be overcome. An incision is made along the inner border of the foot, passing a little below, and then for an inch or two behind and above, the internal malleolus; the sole muscles are retracted ... isolated and retracted,

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completely excised. After the above dissection and forcible adduction of the forefoot, the head of the astragalus will be seen, and can be replaced on the inner side of the foot. The tibialis posticus tendon, if too tight, may be lengthened by splitting and suture above the inner malleolus. The tibialis anticus tendon will not be an obstacle. By this operation no nerves nor important vessels are cut. The foot, well everted and overcorrected, is put up in plaster for about six weeks Subsequently the tendo Achillis can be lengthened by Bayer's subcutaneous method, or by open lengthening

and suture, the posterior capsule of the ankle being divided at the same time.

In inveterate cases in adolescents and adults, where the changes in shape of the tarsal bones, especially the os calcis and astragalus, have become pronounced, and where, in addition to the scaphoid dislocation, the cuboid is displaced inwards, and the neck of the astragalus and fore part of the os calcis are very oblique, the above operation is combined with osteotomy of the os calcis, through an additional outside vertical incision half an inch behind its anterior end, and perhaps also with osteotomy of the astragaloid neck, after which the whole forefoot is abducted and elevated (Elmslie).

The drastic operations formerly in vogue, such as astragalectomy, excision of a wedge from the outer border of the foot, enucleation of tarsal ossific centres, removal of the cuboid, transverse division of the tarsus and Phelps's division of all structures on the inner side, should be obsolete, as they give very poor functional results and cause great liability to relapse.

Congenital talipes equino-varus shows a notorious tendency to relapse, but this is always due to imperfect correction or neglect of the postcorrective treatment. Correction of the deformity is quicker and easier than correction of function; until function is restored, relapse is always liable to occur. Therefore, the corrective methods must be such as will never hamper ultimate function, which depends on mobility and restoration of muscular power. A foot must be soft and pliable. A stiff, hard foot can be used only as a stump in walking, and often progression would be better with a Syme's amputation.

After the correction of deformity is complete, the **restoration of function**, must be carried out sedulously. In children treated from infancy, this will entail assiduous after-care for the next two or three years, and, in older cases, correspondingly longer. During this period the tarsal bones gradually adapt their shapes, in accordance with Wolff's law, to the correct position of the foot, the replaced joints slowly become more supple, the shortened tendons and ligaments become permanently relaxed, and those that were over-lengthened become sufficiently contracted. Massage active and passive exercises, and electrical stimulation of muscles must therefore be continued until full mobility of the foot is obtained and the muscular power and balance restored. The best re-educative exercise is walking, while adaptation is proceeding, but protection will be required day and night by means of boots and night-splints. The boot is wedged on the outer border of sole and heel to favour the valgus or everted position in walking; if more than this is required, a simple side steel is applied on the inner side of the leg from the heel of the boot to a strap below the knee; to this the ankle is pulled in by a T-strap. In cases treated from early *infancy* no walking appliance should be required, other than the wedged boot, and in any case it is rarely necessary to carry the appliance above the knee. The night-splint should hold the foot dorsiflexed and everted The criterion of cure, after which relapse need not be feared, is that the foot be plantigrade, with the heel coming well down and everted; the patient should walk and stand without in-toeing, the foot should be supple in the three main rear joints, so that passive dorsiflexion is possible to 20° beyond the right angle, passive plantar flexion to 60° below the right angle, and passive inversion and eversion complete. Above all, the power must be so completely restored to the peronei and the anterior tibial muscles that the patient can voluntarily evert the foot and dorsiflex it well beyond the right angle without inversion, and the calf muscles must be developed

until there is sufficient power to rise on the toes when standing on the affected foot alone. Persisting in-toeing, frequently ascribed to inward rotation of the tibia, the knee, or the femur, is due to insufficient correction of the adducted forefoot. Nearly always the fault occurs below the ankle, either as an *inward twist of the os calcis or as a persisting midtarsal dislocation.* Very rarely will actual twist of the tibia demand osteotomy, in which case the tibia is best divided very obliquely through a vertical skin incision. Possibly, undue width of the anterior part of the astragaloid facet, preventing mortising between the malleoli in dorsiflexion, may occasionally hinder correction of the equinus; if really so, the posterior fasciculus of the external lateral ligament and the posterior capsule of the ankle-joint may be divided through an open incision, and the external malleolus osteotomized at its base. Where from special circumstances relapse may be feared, preventive methods are adopted The deformity having been already fully corrected, the tibialis anticus tendon is detached from the internal cuneiform and first metatarsal; *the tendon is pulled up from under the annular ligament, and* then inserted into the base of the fifth metatarsal or into the insertion of the peroneus brevis tendon. The suture is made with the tendon drawn *very tight, and the foot is fixed in plaster in valgus position for six weeks.* No possibility then exists of recurrence of inversion deformity. Bankart attains the same end by leading a double stranded thick silk stay from an attachment at the base of the fifth metatarsal to another on the fibula or tibia 3 or 4 in. above the ankle-joint.

Other Types of Congenital Deformity of the Foot

The most common variety, after congenital equino-varus, is *talipes calcaneo-valg* [illegible]
and thin, [illegible]
and the f [illegible]
same principles as described above. Manipulations are begun early and continued regularly, and the overcorrected position is maintained by an outside malleable splint curved in two directions to keep the foot in the equino-varus position The desired result is usually obtained long before the child is able to walk; later he is allowed to walk with the boot raised *at the heel, and with wedges on the* inner border of sole and heel. The other congenital deformities met with are *metatarsus varus* (adduction of the forefoot at the midtarsal joint), pure *plano-valgus*, and pure *varus*.

TALIPES EQUINUS

Equinus or dropped foot is the commonest type of acquired talipes, and occurs either as a simple deformity or as an important element in a compound distortion. Its congenital occurrence in association with varus has been mentioned in connexion with club-foot; and reference is made later (pp. 1053, 1057) to its frequent co-existence with varus or valgus in cases of anterior poliomyelitis and spastic paralysis. Several other causes of equinus deformity remain to be considered.

Normally, passive flexion at the ankle-joint should occur to an angle of [illegible] can occur, from

[illegible]

in children. Some of these cases are possibly congenital, [illegible]

transient infective paralytic attacks; and others, again, may be secondary adaptations to planus or valgus. There is no doubt that in many weak feet, slight equinus is directly responsible for and keeps up the secondary valgus. Women who have constantly worn high heels may develop a contracture of the tendo Achillis which will prevent raising of the balls of the toes to the level of the heel.

When being tested for the equinus deformity at the ankle joint, the patient should sit with the knee fully extended; the foot is then held midway between the varus and valgus positions and is passively dorsiflexed. It will usually be found that the patient can add a few degrees of dorsiflexion by strong active contraction of the anterior tibial muscles. In dropped foot the slighter degrees of associated valgus or cavus deformity must be noted; for even when the tendo Achillis is considerably contracted, passive dorsiflexion may be possible beyond the right angle if the foot is in the valgus position; moreover, foot drop may occur not only at the ankle but also at the midtarsal joint. Plantar flexion of the anterior in relation to the posterior part of the foot exaggerates the long arch, causes a cavus deformity, and increases the dropped appearance of the whole foot; equinus deformity of the posterior part of the foot should therefore be estimated apart from the relation of the anterior and posterior halves of the foot to each other. Recognition of this fact will save many uncontracted Achilles tendons from unnecessary tenotomy.

In extre[illegible]

the back and front of the leg are wasted. The toes are hyperextended at the metatarso-phalangeal joints, partly from the attitude in standing and partly from the ineffectual attempts of the long extensor toe muscles to raise the whole foot. Callosities, and sometimes perforating ulcers, form on the balls of the toes. An equinus foot is often made insecure by a tendency to varus when extreme, and to valgus when slight. In longstanding cases the usual structural alterations occur in the bones of the foot There is a loss of articular cartilage on the front of the tibial facet of the astragalus, and the bone changes may form a decided obstacle to correction after the tightened tissues behind the ankle have been lengthened. The contractures maintaining the deformity involve not only the Achilles tendon, but also the posterior part of the capsule of the ankle-joint, which, therefore, may need free division before reduction can be accomplished. Bankart has pointed out that the fixity of the deformity or rate of progress of contracture of the posterior muscles depends on the cause. When the deformity results from total paraly[illegible]
very [illegible]
stretc[illegible]
of rigid deformity is much more rapid The contractures of paralysed calf muscles are due to fibrosis during degeneration, but the contracture of a non-paralysed calf muscle occurs from want of the impulse for lengthening which normally should come, by reciprocal innervation, from the now inactive antagonistic anterior tibial group. The unparalysed calf receives no impulse for elongation, and this power is therefore lost.

Acquired equinus deformity may result from—(*a*) Anterior poliomyelitis and (*b*) upper-neurone lesions, both already mentioned. (*c*) Neuritis, whether traumatic, infective, toxic, or degenerative; in the toxic and infective forms it is usually bilateral. (*d*) Trauma to nerves, e.g. after injuries of the lumbo-

sacral plexus during childbirth, or after wounds, stretching or compression of sciatic, external *popliteal, or anterior tibial* nerves. (*e*) Spina bifida (although calcaneo-valgus is commoner). (*f*) Friedreich's disease (hereditary ataxic paraplegia). (*g*) Myopathy, in which it may be associated with hypertrophied calves, or with varus deformity in the Charcot-Marie-Tooth type of dystrophy. (*h*) Local disease, e.g. arthritis of the ankle. (*i*) Injury, e.g. fracture near the ankle; in fractures of the tibial shaft it *may be due at first* to spasm and later to infiltration of the calf; in adults, especially, it may [illegible] (*j*) Compensation for real shorten- [illegible] *with flexed* contracture of hip or [illegible] back of the leg resulting from burns, ulcers, cellulitis, or injuries of soft parts. (*l*) Gravity and the weight of the bedclothes, as in "talipes decubitus," acting in a debilitated patient; in most of these cases, however, there is actual disease involving bones or joints, or some, perhaps temporary, weakness of dorsiflexors or spasm of calf muscles; very little dropping of the foot is likely to occur from gravity and weight alone, even after prolonged confinement to bed. (*m*) Flat-foot (*already mentioned*). (*n*) *In childhood a spurious equinus deformity may* be exhibited, e g. in the tiptoe gait sometimes adopted in learning to walk or, in older children, to avoid pressure on tender epiphyses of the heels; or it may be a manifestation of a purely functional disorder (neuromimesis).

Treatment. [illegible] drop-foot should [illegible] t at right [illegible] l position. [illegible] exercises [illegible] should be kept [illegible] rmly across [illegible] corrective [illegible] ontracture.

It is useless to give a low heel with the idea of stretching a [illegible] *Achillis; the foot is only thrust into a valgus position*, and the arch will flatten before the tendo Achillis will yield. A moderate heel, shoes wedged on the inner side, walking with the feet turned in, and exercises to strengthen [illegible] muscles) will be [illegible] may be palliated [illegible] ed to the same extent if the affected leg is not short.

When *equinus deformity is associated* with real shortening of the leg, the decision to be made is whether it should be corrected, or treated with a specially raised boot. Movement in the ankle-joint following correction of the deformity would further restore power in both muscle groups; *but a boot with a thick sole* is unsightly, and if the heel only is raised and the foot left in equinus position the benefit of the operation is not great. Very considerable degrees of shortening of the leg can be masked by maintaining the foot in an excessive *equinus* attitude, as with the O'Connor type of boot; but as in these cases the weight falls almost wholly on the balls of the toes, the toes themselves are very liable to painful disability from their cramped position.

When the deformity is moderate and due primarily to contracture of the soft parts, it is usually sufficiently corrected by dividing each half of the tendo Achillis subcutaneously at different levels, about an *inch or so*

apart, and effecting the lengthening by overlapping—Bayer's method. If more than an inch of lengthening is required, especially if the gastrocnemius is poorly developed as the result of a previous attack of paralysis, or if there is spasm of the calf muscles as in the upper-neurone lesions, open incision and suture is a better procedure. Tenotomy of the tendo Achillis diminishes the power of the calf muscles for many months afterwards. In oldstanding cases the posterior part of the capsule of the ankle-joint will also need free division. Even after this, complete correction may be impossible on account of the structural changes in the astragalus. Simple tenotomy of the tendo Achillis is not such a harmless operation as one is usually led to believe. If overlengthened, the tendon remains only partly united by a band of thin adherent fibrous tissue, which soon stretches and permits a dropped heel or calcaneus deformity—a serious disability. No re-suture or shortening of such a tendon is of any use, and one of the radical operations recommended for paralytic calcaneus will be necessary.

Various operations have been devised to meet conditions of very severe [illegible]

to the desired angle, and closes the skin wound without suturing the muscle or tendon. Gretsel divides the gastrocnemius where it forms the Achilles tendon, and after retracting and reflecting the muscle upwards, he separates the soleus from its origin on the fibula and tibia, preserving its nervous and vascular supply; he then dorsiflexes the foot to the required degree, turns down the gastrocnemius and sutures it. In these very severe degrees of equinus the author is accustomed to detach the heads of the gastrocnemius from above the condyles of the femur, and all the calf muscles (*excluding the peronei*) from their origins from the posterior surfaces of the tibia, fibula, and interosseous membrane. The vascular and nervous supply is carefully preserved, and the interosseous membrane incised to prevent kinking of the anterior tibial artery. As the foot is brought up into the desired position the calf muscles slide down the tibia and fibula *en bloc*. The results of this operation are extremely satisfactory. In spastic cases, on account of the risk of over-lengthening, it is very injudicious to complete the correction at once, as would be done for the lesser degrees of equinus due to spinal paralyses. The foot should be fixed in a metal splint with a movable joint at the ankle, and the correction increased gradually until the desired amount is attained, this process lasting about a fortnight.

When equinus results from real ankylosis of the ankle-joint, as after infective or suppurative arthritis, an osteotomy through the joint should be done at some subsequent period when the infective process is completely over. The most comfortable and useful position of the foot in a case of ankylosed ankle-joint is that slight degree of equinus which corresponds to the difference in the thickness of the sole and heel of the boot to be worn.

FLAT-FOOT (PES PLANUS)

Physiology and pathology. [illegible]
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the foot is locke[illegible]
stretching of lig[illegible]
lever of the second order, ligamentous strain is minimal, and the muscles are

in full action; the ligaments are slack, the joints unlocked, the arches restored or exaggerated. The shape of the foot during standing is the attitude of *rest*; that in walking is the attitude of *activity*. The alternation of these attitudes of passive support and muscular activity is normal in healthy fee
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tissues of the foot. Ligaments and fasciæ are normally inextensible and prevent subluxation of the joints, but with overuse they stretch and permit deformity.

The exaggerated projection of the inner malleolus, so called "weak ankles," is due to yielding at the subastragaloid joint and not at the ankle. The three posterior joints of the foot, the ankle, subastragaloid, and midtarsal joints, lock when the foot is dorsiflexed and abducted, the deltoid, interosseous, calcaneo-scaphoid, and plantar ligaments and the plantar fascia being then under strain The persistence of passive abduction, *instead of its alternation with the plantar flexion and adduction characteristic* of muscular activity, or the exaggeration of the normal valgus position of the foot, is one of the first signs of a weak foot (Whitman). *Pes valgus*, or *abducted* foot, must not be confounded with *pes planus*, wherein the long and transverse arches are depressed Most cases of acquired flat-foot begin as an abduction or valgus deformity, and the long arch yields later. When a normal foot takes weight, its inner border becomes straight instead of concave, eventually becoming convex as deformity occurs The long arch is slightly flattened, and the transverse arches also Thus the foot normally yields to a certain extent in weight-bearing, due to movements in the tarsal joints; an exaggeration of this constitutes deformity, although not necessarily disability. As the forefoot becomes more abducted, or the toes turned out, the body-weight falls more and more towards the inner border, and the deforming effect of gravity increases. In valgus deformity the astragalus tends to roll in over the inner border of the foot, and the os calcis to topple inwards. The ankle overhangs the bearing surface of the heel on the inner side, and the head of the astragalus projects on the inner border. It is when the midtarsal joint yields that planus is added to valgus; then the forefoot becomes abducted and relatively dorsiflexed. The posterior half of the foot points inwards and falls inwards, while the forefoot points outwards The inner border is further depressed, and the head of the astragalus and the tuberosity of the scaphoid become very prominent. The inner border of the foot is lengthened The forefoot, besides being abducted, is in severe cases rotated outwards, so that the sole tends to face somewhat outwards Planus is very uncommon in children, except in infants, whereas valgus or "weak ankles" is frequent.

A deformed foot is not disabled if the movements in the joints are complete. Therefore the essential in treatment is to restore full and painless active movement. The restoration of mobility depends on the cause of the restriction; a foot stiff and painful from adhesions can be made supple by manipulation under an anæsthetic, but, if articular changes have already occurred, forced mobilization would be worse than useless.

General clinical features.—In pure flat-foot of inherited or racial origin the foot is very mobile, and if the muscular control is complete, as it often is, the foot is functionally perfect, although flat. Children frequently have weak or valgus ankles, which, however, are rarely painful, although the gait may be ungraceful and the deformity considerable. Children have greater adaptive ability; their ligaments have never been strong, or have stretched so gradually that no pain is produced. In adults, on the other hand, with slight or apparently no deformity, the strain on the calcaneo-navicular and deltoid ligaments and the plantar fascia causes acute pain, sometimes a tearing sensation, and these structures are tender on pressure. The patient complains of pain, worse after standing or walking, especially along the inner side of the foot, below and in front of the internal malleolus, and along the outer side of the foot; this may also extend up the calf and the inner side of the leg. Effusion takes place into the tendon sheaths, and the ligaments may be swollen and congested.

valgus." The use of the foot with the joints locked causes at first synovitic and, later, arthritic manifestations—loss of cartilage and osteophytic formation, with further fixation and pain—traumatic or mechanical arthritis. Adhesions occur in the tendon sheaths and joints, the muscles of the leg and foot atrophy, the dorsiflexors, evertors, and calf muscles become contracted, and the tibialis overstretched. Swelling, congestion, and sweating also occur from vaso-motor causes.

Etiology.—Most cases of flat-foot are due solely to *mechanical conditions*—weakness of the foot relative to the work demanded, bad habits of function, and improper footwear. These mechanical factors operate in all cases, whatever the immediate cause of the flat-foot. In some cases, however, there are definite exciting causes, such as *trauma* and *infection*. In some the valgus deformity is the more obvious, while in others planus is the chief feature; in still others these elementary deformities are combined.

The **common varieties**, classified etiologically, are—

(1) *Congenital* flat-foot, which may be a pure valgus, or more frequently a calcaneo-valgus. Actual flattening of the arch as a congenital deformity is rare.

(2) *Infantile* flat-foot, which is observed soon after the child begins to walk. It may be purely mechanical in origin, as in fat or rickety infants of poor muscular development or tone. Both valgus and planus are present. If the deformity progresses, genu valgum and recurvatum supervene. In-toeing, so frequently found at this age, is the child's effort to relieve the strain on the ankles and knees, and is a sign of spontaneous recovery

... Loss
... valgus,
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and to contracture of the tendo Achillis. Very severe planus may be met with in spastic paralysis from the same reason.

contracture of the tendo Achillis is probably the effect and not the cause of the foot deformity. *In adult women with weak and painful feet the* tendo Achillis is frequently short; in some of these it has persisted from earlier life, while in others it is caused or *exaggerated by wearing unduly high heels.* To overlook a short heel tendon in a case of *flat-foot is to make* the usual remedies—boots, supports, massage and exercises, walking and standing drill—quite unsuccessful. The treatment of the *short heel tendon* depends on the age and other circumstances of the case. *Slighter degrees* in young children will react to passive stretching and to active exercises with the feet inverted. More resistant cases will require a light metal splint *with* the foot-piece dorsiflexed and inverted to keep up the stretching at night. Or it may be desired to lengthen the tendo Achillis by the subcutaneous lengthening of Bayer, followed by fixation of the foot and leg *in a* plaster or splint for two or three weeks. In adult cases tenotomy is rarely needed, and it is sufficient to raise the heel of the shoe, and at the same time apply wedges to hold the foot adducted.

The movements of the *subastragaloid and midtarsal joints* are best considered together, they are important in balancing, and in the completion *of plantar flexion in walking. There should be an inversion-eversion range* of 60–70°. Adduction is more liable to be restricted. In advanced cases this is due to adaptive or accommodative contracture of the peronei tendons, *and of the ligaments and soft tissues on the outer side of foot and ankle, or to* adhesions, or to spasm. In still more advanced cases the restriction is due to alteration in shape of the tarsal bones, and this severe structural type has, in the past, been treated by resection operations, such as that of Ogston. In this operation the long arch is restored and prevented from relapse by a partial resection of the astragalo-scaphoid joint, with the production of bony ankylosis; it is now obsolete, as restoration of the arch is of no importance in a rigid foot. A foot rigid on account of ankylosis or arthritic changes, but painless, is best left [illegible] may result from adhesions in and [illegible] examined under [illegible] adhesions should be broken down and an estimate made of the amount of adaptive contracture existing. The ligaments must not be torn. In many cases of painful foot, obviously not acutely traumatic or inflammatory, and in which there is only slight or no restriction of movement, general stretching of all the joints under an anæsthetic, followed up by exercises and complete functional use, causes a cessation of all pain. If no contracture exists after the manipulation, and the movements are therefore quite free, immediate *use must be insisted upon,* assisted perhaps by massage and passive exercises, and by suitable boots and supports. Contracted tendons, such as the peroneal and the tendo Achillis, are tenotomized, and resisting ligaments, such as the external lateral ligament, are divided subcutaneously. The foot is then fixed in plaster of paris in the overcorrected position for three *to six weeks,* and the patient may, with advantage, be allowed to walk about in the plaster (to which a sole plate is fixed) in three or four days. On the removal of the plaster, physico-therapy and muscle re-education *are begun, to restore mobility* and increase power, but unassisted weight-bearing is forbidden until function is good enough to make relapse improbable. Walking is at first permitted with the foot protected by wedged boots, arch-*supports, and possibly an outside* leg steel, with ankle strap, the re-education proceeding the while. Instead of a visible side steel, a concealed jointed spring may be inserted between the leathers on the outer side of the boot. *The extent of support is* gradually lessened as the foot becomes stronger.

In advanced cases with severe planus, valgus, contracture of the tendo Achillis and of the peronei, and in which the midtarsal joint is broken down, and the posterior half of the foot plantar-flexed, everted, and adducted at its fore-end, while the forefoot is dorsiflexed, everted, and abducted, the correction may need to be done in two or three stages. But it is in these cases usually that the shape of the tarsal bones is so altered, and mechanical arthritis so severe, that the benefits of extensive correction are so poor as to make it rarely worth while.

A foot may become flat because *the work demanded of it is disproportionate to its strength.* The body-weight may increase, or standing may be too prolonged. Standing is much more harmful than walking, in that the regular alternation of attitudes of rest and activity, the sparing of ligaments by muscles, and vice versa, does not occur. Muscular and ligamentous strength may be deteriorated by general illness and recumbency. Bad hygiene, including bad health, insufficient food, long hours, laborious occupation of adolescents, and too much standing in children, also lessens the efficiency of the foot. The two things which predispose most to flat-foot are (1) improper habits of walking and using the feet, and (2) ill-shaped footwear.

Foot-drill. In standing, a little eversion of the feet is normal, but not in walking To walk correctly the feet are kept parallel as to the inner borders, except at the end of the stride, when the big toe should turn in towards the middle line and the push-off be made on the balls of all the five toes and the toes themselves In the step, weight falls first on the heel, then rather more on the outer than the inner border of the foot, and finally on the toes. This sequence necessitates a gentle toe-and-heel action. This is the essence of educative foot-drill, which is carried out after contracture and rigidity have been overcome. Exercises are usually prescribed, but more important is the training to assume a correct standing posture and proper habits of walking. Exercises are supplementary, and are especially directed to the strengthening of the tibiales anticus and posticus, the flexors of the toes, and the dorsiflexors of the ankle; the exercises are usually preceded by baths and massage, and by passive movements.

The relation between the degree of deformity and the consequent disability in an overstrained or flat foot varies enormously, and depends largely on the age at onset and on the duration Children have much deformity with little pain, while the reverse is common in adults. Pain in the ligaments and plantar fasciæ in adults, in the absence of an infective process, denotes progressive deformity. If the condition is very acute, with swelling of the joints and tendon sheaths, or with muscular spasm, absolute rest off the feet may be necessary. If walking is permitted it must be limited, and then only in boots that give full support. Strapping the midfoot and the ankle-joint in a transverse or figure-of-eight way may be sufficient for a mild attack of ligamentous strain.

Flattening of the arches (planus) is of no practical importance if the feet are supple and painless; only such boots and supports are required as will serve to prevent increase of deformity. Flattened arches and overstretched ligaments, when the condition is of long standing, cannot be cured in the sense of restoring the arches; it is sufficient to relieve pain and restore suppleness. A valgus or abducted foot can be held in check by wedged boots, arch-supports, moderate heels, and proper use; with these discomfort will be avoided. But in children the outlook is much more favourable as regards correction of deformity; adequately supervised foot-drill and suitably supporting footwear will correct the valgus and restore the flattened

arches. In children valgus (weak ankles) is far more common than real flat-foot (planus), the latter being rare, except in infants who have not long been walking and are the subject of knock-knees and other rickety manifestations. Many cases of weak ankles in children get well spontaneously without treatment. A short tendo Achillis in a child, producing secondary valgus deformity, must not be overlooked, but should be lengthened by tenotomy, or by splints and manipulations.

The *flattening of the anterior transverse arch* formed by the metatarsal heads is a common cause of disability in adults. When severe it is characterized by pain and swelling of one or more of the metatarso-phalangeal joints, usually the second and third, tenderness on pressure, inability to bear weight on the front of the foot, and by callosities beneath the affected joints. Normally in weight-bearing this arch becomes flattened, and all five metatarsal heads take weight, and should share with the toes in the push-off in walking. When the arch is permanently depressed most of the weight falls on the heads of the second and third metatarsals, or on a triangle formed by the heads of the first and second metatarsals and the inner side of the distal phalanx of the big toe. Almost invariably a depressed anterior transverse arch is associated with hallux valgus, and with hyperextension or clawing of the smaller toes. The flexion function of the smaller toes is lost, and that of the big toe, so important in sustaining the long arch, is impaired. Thus in walking an undue strain falls on the local area of one or two metatarsal heads, the forefoot is splayed, and the width of the foot at the level of the metatarsal heads is very much increased. Even when no weight is being taken, a hollow appears on the dorsum just behind the toes, bridged by the extensor tendons. The distance between the metatarsal bones, especially the first and second, is increased. In the more acute condition one or more of the metatarso-phalangeal joints may be very swollen and tender, but X-ray evidence reveals no arthritis, except perhaps in the big toe-joint. The deformity of the toes and the depression of the anterior transverse arch, as here described, is almost invariably due to too short and too pointed shoes, which encourage hyperextension of the toes and thus flatten the anterior transverse arch, and hamper the complete toe-flexion range that preserves this arch. The depression of the arch is also favoured by soles which are too thin and concave from side to side.

Morton's metatarsalgia.—In this condition there is little or no deformity, only a mere broadening of the metatarsus, with neither callosities nor swollen joints, but with pain of severely neuralgic type. It is to be distinguished from the pain and disability associated with the gross depression of the anterior arch just described, and is an acute pain, usually of sudden onset, occurring most commonly in the region of the fourth metatarso-phalangeal joint. Sensations of burning, numbness, or cramp may accompany or precede it. The pain is at first localized, but soon becomes very severe, and may radiate to the dorsum of the foot, or up the leg. The attacks may vary in frequency, are usually set up by some activity, and are only felt when the shoe is being worn. Usually nothing abnormal is seen in the joint, either clinically or radiographically. The pain is gradually relieved on removal of the shoe. It is more common in excitable females of adult age. Morton thought the pain was due to compression of the plantar nerves by adjacent metatarso-phalangeal joints, and *advocated excision* of the head of the fourth metatarsal to relieve the pressure. Whitman thinks the characteristic pain is caused by the pressure of an *unsuitable* shoe producing over-riding of the fifth metatarsal bone, and maintains that this explains the sensation of something slipping which is sometimes experi-

enced, and the relief on removal of the shoe. Although in Morton's typical neuralgia the foot may appear normal, he thinks that the neuralgia is but a symptom of weakness of the anterior arch. For pain in the anterior arch shoes must be provided which are long and roomy enough to prevent compression of the toes and permit their flexion function; the sole should be stout, and flat from side to side. The heel should not be too high, and the long arch must be well supported. Strapping the foot very firmly, transversely immediately behind the metatarsal heads, usually gives considerable relief; it may be combined with an anterior arch-support of metal or sponge rubber in the shoe fitted just behind the depressed metatarsal heads; or a metatarsal bar of leather may be nailed obliquely across the sole; or the strapping may include a felt pad on the sole just behind the tender joints. Acute pain or swelling demands rest off the feet for a week or more. In the chronic stage, with the idea of promoting flexion function of the toes, special exercises should be given, preceded if necessary by tenotomy of the extensor tendons and subsequently holding the toes down into flexion for several weeks by the use of the half sole plate and tapes. Recently it has been held that the dorsal interossei muscles are important in bracing the metatarsal bones together, and the special treatment of these small muscles by interrupted faradism appears to have had satisfactory results (Levick).

PES CAVUS ("CLAW-FOOT")

frequently associated with slight inversion or varus deformity, due to weakness of the peronei muscles, and occasionally with a real shortening of the tendo Achillis. The term *arcuatus* is sometimes applied when the deformity is confined to the long arch; and *plantaris* when also the tendo Achillis is shortened In the compound distortions of the feet mentioned earlier in this article, the exaggeration of the long arch may be only an element of the more general deformity of the foot

Etiology.—The etiology is sometimes obscure, but the following conditions are often associated (*a*) Heredity—an inherited peculiarity. (*b*) Persistent use of high heels and short shoes. (*c*) Very occasionally improper training in toe dancing (*d*) Types of compound deformity, such as equino-varus, calcaneo-valgus, and equino-cavus where the cavus in itself is not

deformity involves one foot only, and the diagnosis will be founded on the existence of slight shortening of the leg and foot, associated with a slight degree of equinus, rather than on the history. (*f*) Spina bifida occulta is often associated with a typical pes cavus, either unilateral or bilateral, quite a different shape of foot from that associated with the more obvious meningocele, it may not become apparent until the age of adolescence; it is liable to be progressive and to be associated with perforating ulcers and incontinence of urine. (*g*)

reich's ataxia, progressive

erative neuritis. (*h*) Habi

ening of the leg, and then associated with more or less equinus. (*i*) Inju to the posterior tibial *nerve*. (*j*) Ischæmic paralysis of the leg muscles.

The most *typical form* of pes cavus is that which becomes troubleso only in later adolescence, and is *frequently bilateral*. There is oft no history of a definite causative disease, but the feet may have been troub some since childhood. It is probable that, excepting the few which due to infantile *paralysis*, *most of these* cases result from transi neuritis occurring *in the course of a* specific fever, such as scarlet fev diphtheria, etc. The existence of bilateral deformity is in favour of *toxic neuritis* In other cases the etiology is very obscure, no other sig indicative of disease of the *nervous system* being found. In these cas which are yet apparently *of nervous origin*, the deformity is far more pr gressive than in the infective type.

Physical signs (Fig. 895).—The foot is hard and unyielding, esp cially at the midtars joint, and the dorsu may be prominent, cau ing difficulty in lacin the shoe. As a rule th arch of the outer bord of the foot is increase proportionately with tha of the inner, but in som cases, particularly in thos occurring in early lif the arch of the inne border is more exagger ated, the head of the firs metatarsal being drawn back to the level of tha of the fifth. The planta fascia is shortened and prominent, and the con tracture also involves the plantar ligaments and the muscles of the sole; the latter may appear to be considerably wasted. The contraction of the sole limits dorsiflexion of the forefoot at the midtarsal joint Nearly all cases have some varus of the whole foot or of the fore-foot only; the former is probably due to peroneal weakness, and the metatarsus varus to more powerful intrinsic action on the great toe. The weight of the body falls on the heel and metatarsal heads only. Because they are hyperextended and clawed, the toes have no flexion power, and all the strain of the push-off in walking falls on the metatarsal heads The anterior arch is depressed, the balls of the toes are painful, and corns form on them. Corns form also on the prominent dorsal knuckles of the toes. The whole foot is shortened from front to back. When the Achilles tendon is shortened, the strain on and discomfort in the forefoot is greater; and if the peronei are not weak the foot is thrust into valgus. Apart from the deformity and troublesome corns, the patient complains that the feet are stiff, uncomfortable, and easily fatigued, and finds it difficult to obtain satisfactory boots. The condition of the toes is comparable with the *main-en-griffe* deformity of the hand in ulnar and median paralysis



Fig. 895.—Pes cavus, with clawed toes.

The cavus deformity is the result of a transient primary paralysis of the intrinsic muscles of the foot, which extend the interphalangeal and flex the metatarso-phalangeal joints. If the intrinsic muscles are temporarily paralysed, the long extensors and flexors of the toes can only hyperextend the metatarso-phalangeal and flex the interphalangeal joints. The exaggeration of the claw deformity in the big toe is due to its stronger long-muscle action. After the production of the claw toes the long and short extensor tendons become permanently contracted. The bases of the proximal phalanges rest on the dorsa of the metatarsal heads, which consequently drop, being pulled down by the recovering intrinsic muscles, whose line of action is now permanently above the transverse axis of movement in the metatarso-phalangeal joints. Under these conditions the intrinsic muscles can act only as extensors of the toes at the metatarso-phalangeal joints (instead of flexors as normally); their flexion function cannot be restored until the extensor tendons have been lengthened and all other passive restriction to flexion at the metatarso-phalangeal joints completely overcome. The cavus is further increased by secondary contracture of all the soft tissues of the sole, and later becomes even more fixed by the adaptive changes occurring in the tarsal bones.

Investigation during operation always shows healthy intrinsic muscles, so that any paralysis must have been transient. The plantar fascia is thickened and contracted, and the abductor hallucis muscle contracted also. The accessory insertions of the tibialis posticus tendon are very dense, the extension to the forefoot often being thicker than the main tendon before its insertion into the tubercle of the scaphoid. Occasionally the peronei muscles, especially the peroneus longus, are found to show signs of degeneration.

Treatment.—Incipient cases *in children* must be watched carefully, the arch kept flat by daily passive stretchings, the toes straightened, and

[illegible] may be necessary to divide the plantar fascia subcutaneously to flatten the arch, and fix the foot for three or four weeks in plaster of paris with the toes flexed at the metatarso-phalangeal joints. If the extensor tendons are tight they may be tenotomized, but this is rarely necessary in children. On removal of the plaster, exercises and massage, as well as the night splint, may be continued, and if necessary the toes may be taped down to a leather insole in a specially broad boot. The tendo Achillis must never be lengthened unless undoubtedly short. The mistake of unnecessarily lengthening this tendon is frequently made, resulting in increase of the cavus disability.

In cases coming for treatment *during adolescence*, it may be sufficient to raise the heel slightly and provide a boot with a strong well-curved and well-fitting waist, and wedged on the outer border of the sole and heel to correct any slight varus tendency. The specially-shaped waist in the boot increases the bearing surface of the foot and relieves the heel and balls of the toes from undue pressure. A bar across the sole immediately behind the metatarsal heads will relieve tenderness in the balls of the toes. An arch-supporting plate within the boot will even more advantageously distribute the weight throughout the foot; this can also be raised in front to lift the anterior transverse arch and relieve the heads of the metatarsal bones from pressure. The effect of such an accurately fitting sole plate is, in time, to lessen the arch, and not increase it. In these older cases open

or excision of the plantar fascia has now given place to the operation of Steindler, who, by means of a horseshoe-shaped incision around the outer and posterior aspect of the heel at the level of the lower margin of the os calcis, detaches the plantar muscles, fascia and ligaments from their origins on the inferior surface of the os calcis, and allows them to slip forward as the long arch is wrenched flat. This operation is sufficient to correct mild degrees of deformity in young people, but in adults, and in more considerable degrees of cavus, the writer prefers to combine the Steindler operation with division of the ligaments on the inner border of the foot. The tibialis posticus tendon is isolated, and all its insertions except that into the tubercle of the scaphoid are divided. The internal and inferior calcaneo-navicular and the scapho-cuneiform ligaments are cut across, and also every deep ligament in the sole of the foot that has not already been divided through the Steindler incision. A little wrenching will now break through any fibres that may have been overlooked, and the long arch can be made as flat as desired; there is no danger of overdoing the correction. The foot is put up in a moderate degree of correction in a right-angled splint for a fortnight, after which the stitches are removed, the correction completed, and the foot and leg fixed in plaster of paris. The plaster should be retained three or four weeks, the patient being allowed to walk about on it if possible. The usual after-treatment will be required for some time, which will depend on the amount of accommodative change that has already taken place in the tarsal bones. A supple and comfortable foot, and very good function as well as correction, are attained in the majority of cases.

The treatment of the claw-toe deformity will usually be undertaken after the cavus has been rectified, but in some cases the toes form the major part of the disability, the cavus being so slight as not to require operative interference. To restore the function of the toes, it may be necessary to tenotomize the extensor tendons, and also the dorsal capsules of the metatarso-phalangeal joints, in the effort to correct their deformity. If practicable, the toes are held down in a good position to a sole plate by means of tapes, and faradic electrical treatment is undertaken, as well as active flexion exercises, to strengthen and alter the line of action of the interossei. After the arch and toes have been rectified, some tendon transplantation may be necessary to correct the varus, maintain power of flexion of the toes, and prevent relapse of the cavus; these operations are described under Infantile Paralysis (p. 1066).

For useless feet with protracted and very severe deformity, amputation of the toes and removal of the metatarsal heads, or a cuneiform tarsectomy, may be necessary, the wedge being taken from the dorsum of the foot.

Perforating ulcers should be excised, together with the subjacent head of the metatarsal bone.

HALLUX VALGUS

[illegible] the big toes are hallux valgus and [illegible] tatarso-phalangeal joint is deranged. [illegible] aterally outwards from its normal alinement with its corresponding metatarsal. The deformity is very rarely congenital, and there is little hereditary disposition. It is an acquired deformity of mechanical origin, the result of wearing shoes that are too short and

pointed, and that have narrow and constricting toe-caps; tight stockings may also assist. The deformity is predisposed to by the improper habit of walking with the toes turned out, so that the push-off is exerted on the balls of the big and second toes and on the inner side of the distal phalanx of the big toe. It is usually accompanied by depression of the anterior transverse arch formed by the metatarsal heads, and by adduction and clayed deformity of the four outer toes. It is often associated with flat-foot, or lowering of the long arch, and either condition may predispose to the occurrence of the other. Sometimes, however, especially in adolescents, a severe hallux valgus deformity is found in conjunction with a long arch that is quite normal. Ellis has pointed out that one of the main supports of the long arch is the powerful action of the flexor longus hallucis; this action necessitates a free flexion range of movement of the big toe in the axis of its metatarsal. A hallux valgus has very little power of active flexion, and therefore the deformity must lessen the muscular support of the long arch. The depression of the arch increases the length of the inner border of the foot, making the

only the terminal phalanx.

The deformity of the big toe itself is only one part of the condition. Of equal importance is the deviation of the first metatarsal from the second. The pressure on the inner side of the big toe is exerted directly backwards towards the outer aspect of the metatarso-phalangeal joint, or even outside it altogether. The base of the proximal phalanx is twisted round towards the outer aspect of the metatarsal head. The head of the bone is deflected inwards, but the base of the proximal phalanx is tethered by the adductor muscles of the big toe. The ligaments on the outer side of the joint become contracted. Adaptive changes occur in the shape of the proximal end of the metatarsal and in the internal cuneiform bone. The axial alinement of the big toe and its metatarsal having been disturbed, the line of action of the long extensor and flexor tendons of the toe, which are now displaced towards the outer side of the joint, exercises a vicious effect in maintaining and increasing the deformity The pressure of the boot on the now projecting inner side of the metatarsal head leads at first to redness and irritative bursitis; later the irritation involves the bone, and exostosis-formation

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jacent

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the duration of the deformity. At first the articular cartilage on the head of the metatarsal is not much changed, but only diminished in the inner part. In elderly patients the movements in the joint become further restricted, the articular cartilage erodes, and a definite traumatic or mechanical osteo-arthritis is set up. Enlargement, irregularity, and lipping occur freely in the sesamoid bones In hallux valgus it is rare to find the articular movements extremely restricted, immobility being more characteristic of hallux rigidus; generally speaking, these two conditions do not occur together. The outward displacement of the big toe continues until limited by impaction against the lesser toes. The second toe may have been pushed into a position of flexion, causing a hammer-toe, or it may lie on the dorsum of the big toe. In extreme cases of hallux valgus the big toe may become almost transverse in position.

The patient finds walking difficult and tiring, and the usual symptoms

of flat-foot occur. The boots irritate the bunion, and there is frequently local pain and burning from direct pressure. The anterior transverse arch may be so depressed that weight is taken *almost wholly upon the heads of* the second and third metatarsal bones, the joints of which become very inflamed and tender.

Treatment.—The tendency to deformity in young children must be met by the use of boots of sufficient length, and with straight inner borders *to allow room for abduction of the big toes; nor must the stockings be short.* The boots must be wedged along the inner borders, and great attention paid to training the child to walk toeing-in. Daily passive manipulations are [illegible] of a splint at night. Active [illegible] on exercises for all the toes, [illegible]

will usually be necessary. When, however, the child is about 10 years of *age or over, manipulative and splint treatment is very slow and disappointing,* and some operative course, therefore, should be followed. In a young or adolescent child it is worth while undertaking some radical correction of the deformity. In no circumstances at this age must the head of the bone or the base of the phalanx be removed. Any operation, to be successful, [illegible]

of the metatarsal is useless, and relapse is inevitable. Any good that may seem to accrue will be derived from the subsequent splinting and other treatment. [illegible] The inner side of [illegible] inner side of the h[illegible]ad, is split off in a vertical plane, the line of section issuing on the mesial side about the middle of the shaft. No attempt must be made to smooth the remaining portion of the he[illegible] at its base immediately [illegible] strongly, and into [illegible] bone made from the exostosis just removed. The wedged graft [illegible] [illegible] *subsequently,*

the big toe is manipulated into a varus position, and is partially [illegible] over the raw surface left on the inner side of the head. *The split capsule* on the inner side falls over the raw bony surface, and becomes adherent to it. No deep suturing is necessary. A malleable splint is applied to keep the big toe overcorrected, and is retained for a month or five weeks, the patient remaining recumbent during that time. At the end of the second *week from the operation the splint can be removed temporarily for massage* and active and passive movements (the latter at first being very gentle); meanwhile the special boots with toe-posts are prepared. Walking is not permitted except in these boots, and then not until about five weeks *after* the operation. The protection by boots and night-splints, and the massage and exercises, *must be continued for six months at least.*

The indications for operation in the middle-aged adult are not so much

the correction of the deformity in the radical manner described, as relief from tedious pressure on the bunions. It will generally suffice merely to remove the exostosis together with about one-third of the thickness of the head of the bone, and also the thickened bursa and redundant callused skin. Some of the deformity is naturally corrected by this operation, especially if splints be worn while the patient is lying up for a fortnight, and continued afterwards at night. It is important, in order to restore the mobility of the big-toe-joint, to continue regular exercises and massage for about six weeks after the operation

In the very worst cases, when the joint is very arthritic and painful, especially if the anterior arch is also causing much disability on account of its depression, the head of the bone may be totally excised, the sesamoids being left. Turning in a flap of fatty or bursal tissue between the bone-ends appears to be of no material advantage in the subsequent restoration of movement

Although excision completely corrects the deformity, it is only a measure of palliation, as the great toe remains practically functionless. Moreover, it removes one of the most important weight-bearing points of the foot. If the anterior arch has not already given trouble, on account of pressure upon the heads of the second and third bones, it soon will after an excision of the first metatarsal head, unless a plate to support it be worn permanently. Excision of the head of the metatarsal bone is an easy but very much over-rated operation, and the indications for it should be definite. It is very rarely indicated in hallux valgus, but is of more use in hallux rigidus. The alternative operation of removing the articulating end of the proximal phalanx, in lieu of the head of the metatarsal, is not so destructive of the stability of the foot; after this operation the joint may be movable, but the toe, although straight, will fulfil no function.

HALLUX RIGIDUS

This condition is frequently overlooked as a cause of disability because in the majority of cases there is no coexisting deformity The primary lesion is a destructive arthritis of the big-toe-joint, with the usual disabling symptoms of pain, stiffness, and weakness which characterize osteo-arthritic joints elsewhere in the body But the symptoms in hallux rigidus are particularly severe as the big-toe-joint has to sustain so much weight. The arthritis is usually, though not invariably, of mechanical or traumatic origin.

Etiology.—The cause of hallux rigidus is most commonly injury due to chronic stubbing of the toe from wearing shoes too short and too pointed. The condition, usually bilateral, may progress insidiously, with little pain at first, but with gradually increasing restriction of movement, especially in dorsiflexion, and with thickening and prominence of the articular edges of the metatarsal head from osteophytic formation. At times the stress of the injury falls not on the metatarso-phalangeal, but on the metatarso-cuneiform joint, giving rise to the exostosis-formation so frequently seen on the dorsum of the foot in adults, and sometimes in young children. In later life the arthritis at the proximal end also of the metatarsal may become very disabling and painful, and necessitate excision and ankylosis of the metatarso-cuneiform joint. Hallux rigidus may also follow an acute injury, as sudden stubbing, or a blow on the joint Either the phalanx or the metatarsal bone may be injured. Occasionally the condition results from injury to the epiphysis of the proximal phalanx. At times the epiphysial head of the second or third metatarsal bone shows a like condition. A rigid

big-toe-joint may be associated with a flat-foot, and is then probably due to the pushing forwards of the big toe against the toe-cap of the shoe in the relative lengthening of the inner border of the foot.

Signs and symptoms.—The patient complains of aching pain in the joint, which is *frequently swollen* and tender; often the pain is felt particularly in the outer part of the dorsal aspect of the joint. The joint is limited in *movements, particularly in* dorsiflexion, but plantar flexion is not lost so readily. The *patient cannot rise* on the *big toe*, and forcible attempts to do so cause considerable pain, or lead eventually to a compensatory hyperextension of the *interphalangeal joint*, which later may become painful. The big-toe-joint becomes progressively *stiffer. At times a fixed* flexion deformity results—*hallux flexus*—described by Davies-Colley, in which weight is not taken on the joint itself, but falls upon the interphalangeal joint, beneath which a painful corn or a perforating ulcer may develop (Fig. 896.) To avoid the jar of weight-bearing upon an arthritic big-toe-joint, the patient walks on the heel, without any spring, taking the weight chiefly on the outer border of the foot, and holding the forefoot in varus and the lesser toes adducted.



Fig. 896.—Hallux flexus.

The joint itself shows all the signs of traumatic or hypertrophic osteoarthritis. The cartilage erodes in patches, and eventually disappears. Osteophytes form, particularly on the outer and dorsal aspects of the metatarsal articular edges. Patches of granulation tissue appear at the edges of the cartilage, where the adjacent lips of the two bones impact on each other. Occasionally a large osteophyte, with superimposed bursa- or bunion-formation, projects on the dorsum, beneath or to one or other side of the [illegible] The joint cleft, [illegible] flattened from [illegible] thritic process. The restricted movement is due to the mechanical impaction of osteophytes, and to the contracture of the capsule and ligaments—a spurious ankylosis.

Treatment.—A rigid toe-joint is not necessarily painful; in fact the pain will quite disappear when movement is abolished, if the joint is not strained and adequate protection is afforded by the boot. Excision of the head of the bone, although restoring a certain degree of movement, gives such a poor restoration of the power and leverage action of the big toe that it is indicated only for pain and not merely for stiffness. As a preventive and palliative treatment, shoes of adequate length should be supplied,

so that no pressure is exercised either on the tip or on the inner side of the great toe. Toe-caps are best avoided, and the "upper" of the shoe should be roomy enough to cause no pressure on the top of the joint. The sole should be stout and rigid, to prevent unnecessary forced hyperextension movement. A metatarsal bar immediately behind the heads of the bones will relieve some of the weight on the joint itself; wedging of the inner border of the sole and heel will have a similar effect. Although the patient may be suffering from flat-foot, strenuous exercises, such as standing upon the toes, must not be advised, for movements of this character irritate osteo-arthritic joints. On the other hand, massage preceded by heat and followed by gentle active and passive exercises will help to restore suppleness without irritating the joint. If the long arch is depressed, a well-fitting support will serve both to shorten the inner border of the foot and relieve the big-toe-joint from undue weight.

Hallux rigidus is frequently met with in children entering adolescence; the joint is very stiff and painful, it may be swollen, and the toe is inclined to flexion deformity. Some of these cases are *traumatic* and some are *infective* in origin. Skiagrams may show no joint changes whatever, and under an anæsthetic the rigidity [illegible] If the condition is in quite an early [illegible] boots and weight-bearing, combined [illegible] movement. But if adaptive changes [illegible] be gently dorsiflexed, and fixed in plaster of paris for two or three weeks, after which the correction can be further increased, and the plaster renewed for another few weeks. Careful after-treatment on removal of the plaster will restore a perfect joint.

For a joint which remains vulnerable and painful in spite of all palliative treatment, excision is the only hope. The removal of osteophytes is limited to an operation upon one particular prominence which in itself may be causing trouble. Extensive removal of osteophytes from the metatarsal head and shaping-up the end of the bone are quite useless for the restoration of further movement, as the joint is left stiffer and perhaps more painful than before. For severe pain and for flexion deformity Davies-Colley advocated excision of the base of the phalanx, but most surgeons prefer to remove the head of the metatarsal bone. Care must be taken that the great toe does not remain too dorsiflexed after the operation. Pain is relieved, and certainly some movement is restored, but the amount obtained varies greatly in different cases, and is in a measure proportionate to the care and length of the after-treatment. In any case, the big toe remains very weak, and a special support must be worn permanently to prevent depression of the second and third metatarsal heads. It must be emphasized that in no circumstances whatever should the big-toe-joint be excised in adolescents, as the new joint will inevitably ankylose again.

HAMMER-TOE

[illegible]

tended or flexed. A corn and bursa may form on the dorsum over the prominent head of the first phalanx, and on the tip of the toe, adjacent to the nail, which is distorted. The etiology is similar to that of hallux

valgus, with which it is often associated. The longer second toe gives way before the usurping valgus big toe, and becomes flexed and overlapped by its neighbours. Occasionally, however, the reverse process occurs, the

e tip of the hallux. The

adolescence. Treatment

The congenital form, as seen in small children, is bilateral as a rule, and usually involves the middle toe, but sometimes all the three outer toes. The whole toe is flexed, the terminal part being adducted and lying beneath its neighbour on the inner side.

Treatment.—The acquired form would never occur if boots of sufficient length and width were provided for rapidly growing children. The deformed toes should be manipulated and corrected every day, and afterwards retained in a proper position in a special sole plate fitted with elastic loops passing over the projecting joint on the dorsum of the toe. By day this half-sole plate can be worn in specially big shoes The manipulative treatment is very slow and tedious, except in small children. Operative treatment should therefore be freely advocated. The usual operation for the acquired condition is the removal of a transversely elliptical piece of

interphalangeal

and

cular

surface of the second phalanx also, the better to promote bony ankylosis; but too great shortening of the toe should be avoided. The excised joint is *forced into hyperextension, and held thus by the tension of the stitching* and by a short plantar splint for two or three weeks subsequently. The

great toe is thus fostered. If the toe must be removed completely, it is preferable to amputate also the head of the corresponding metatarsal bone. As a reconstructive operation in hammer- and claw-toe, the writer prefers to detach the long flexor tendon from its insertion into the terminal phalanx and to pass it through a hole pierced in the distal part of the proximal phalanx, on the dorsum of which it is sewn to the split extensor tendon by silkworm-gut, and under such tension that the toe is held well flexed at the metatarso-phalangeal joint. *Transverse division of the flexor aspect* of the capsule of the proximal interphalangeal joint will allow the two terminal phalanges to fall into extension, and in line with the proximal phalanx. The toe remains straight and undeformed, and recovers a complete range of flexion.

DEFORMITIES DUE TO PARALYSES OF CEREBRAL AND SPINAL ORIGIN

Paralytic cases fall into two groups.—

1. Those due to defects of the upper-neurone system in its course from the cerebral cortex to the spine—the cerebral paralyses.
2. Those due to defects of the lower-neurone system, or of the spinal nerves, in the course between the reflex spinal centres and the motor-endings in the muscles. In this group may be included diseases of the muscles themselves.

Both forms give rise to deformities of the trunk and limbs, from the

effects of unequal muscle-balance, gravity, and posture. The commonest examples of the first group are infantile hemiplegia and diplegia, and of the second, anterior poliomyelitis, or infantile paralysis.

Clinically, the *cerebral* types are distinguished by absence of vascular effects and of undue muscular wasting, any atrophy present being due to disuse. The limbs are not shrivelled and cold, and not retarded in growth. The reflexes are exaggerated, and ankle-clonus and the extensor plantar reflex are present. Electrical reactions are unaltered The joints are all stiff in passive movement, and active movement and gait are awkward from spasm of the muscles. Mental development may be impaired The striking factor, which presents also an essential difficulty in treatment, is the *inco-ordination or want of control of the limb movements* There is a "paralysis of movement." In *spinal* paralyses, on the other hand, the defect is in the peripheral machinery. There is a paralysis of muscle, wasting is pronounced,
flexes
sent.
rmal.
The actions of certain muscles or groups may be defective, but there is no real inco-ordination. The cerebral or spastic deformities are less amenable to orthopædic measures than those of spinal or flaccid type, because in the former the defect is more central, and the mentality of the patient, so frequently impaired, militates against educative measures for developing muscular control

Cerebral Paralyses

The most common types of cerebral paralyses are. (*a*) *Infantile hemiplegia*—arm and leg on same side involved. (*b*) *Spastic diplegia*—a bilateral hemiplegia. (*c*) *Spastic paraplegia*—only the legs are weak and spastic. (*d*) *Monoplegia*—one limb, usually the leg, affected.

On rare occasions, and then usually the result of infantile paralysis, a combination of cerebral and spinal paralysis is met with, e g. the arm may be flaccidly paralysed from affection of the spinal centres, and the leg spastically affected from involvement of its cerebral motor area.

Pathology and etiology.—These conditions may be due to congenital defects, prenatal syphilis, asphyxial conditions in premature infants, *injuries at birth, or infective disease or injuries of the brain during infancy.* In many cases they are ascribable to cerebral defects or imperfect development of the brain in which heredity plays an important part. There is often a history of nervous disease in the family. This is especially true of paraplegia and diplegia, which are commonly associated with marked mental deficiency. Injuries during labour may be followed by meningeal hæmor-
In infancy
ecific fevers,
arteritis with
thrombosis may be a cause.

Certain groups of muscles are spasmodically contracted, overacting upon their antagonists, and pulling the joints into persistently deformed positions; *eventually the shortening from spasm becomes permanently fixed* by accommodative contracture, and the muscles cannot be stretched by passive effort. The overstretched antagonists become gradually impaired in their power of contraction. The ligaments share in the adaptive process, and finally the bones are altered in shape, and thus the deformity becomes fixed. Degenerative changes occur in the cerebral motor areas and lateral columns of the cord.

History and symptoms

noticed soon af
later. Difficult
serious conditic ... may be noticed to walk on the toes of one foot, with the knee bent, *or with* both thighs adducted. The back is often seen to be weak, and mental deficiency may be shown by the delay of speech.



Fig. 897.—Infantile hemiplegia.

Hemiplegia (Fig. 897).—In this condition the arm is nearly always more affected than the leg, and in the course of time becomes more contracted and disabled from disuse. The leg can nearly always be used, and therefore grows, while the paralysed hand is neglected, for it is incapable of developing complicated functions like the opposite hand. The arm is held slightly abducted at the shoulder-joint. The elbow is usually flexed, the forearm pronated, and the wrist dropped. The thumb is strongly adducted, and the fingers either clutched or extended according to the severity of the condition. Voluntary action of the arm may be almost absent, or show varying degrees of weakness and awkwardness. The foot is in the position of talipes equinus, with slight varus in early cases and slight valgus in late ones The knee and hip are flexed, and the thigh adducted. The equinus may be so extreme that the paralysed limb may appear longer than the other, although it may be in reality a little shorter Accommodative lateral curvature may develop. At first the deformity is due to spasm of the contracted muscles, which are generally flexor. Later on, accommodative real shortening takes place in the retracted muscles and tendons. In some cases the deformity may be limited to one limb—usually the leg The gait is shuffling and characteristic, the paralysed limb being held rigid and used often only as a prop.

Spastic diplegia.—This condition is more likely to be overlooked for a considerable time because it is symmetrical and almost entirely spasmodic at first. Thus there may be talipes equinus as the child lies, which almost entirely disappears when he stands. The weight of the body is enough to overcome the spasm sufficiently to allow the foot to be flexed to the right angle. But in a normal child the foot can be flexed so that its fore part is about 2 in. higher than the heel. In addition to the equinus there may be slight varus or valgus. The knees may be flexed and the thighs adducted and flexed. The adduction may be so great that the knees are crossed. In severe cases the back is weak and kyphotic. Usually there is some irritability. Efforts at voluntary or passive movement, and excitement, increase the spasm. There is little or no wasting of the leg,

but walking is difficult or impossible on account of spasm and loss of control of the muscles, with resulting deformities. Often a squint is present, and the facial appearance may be very suggestive of mental deficiency.

In a large proportion of these severe types of upper-neurone paralysis there is moderate mental deficiency and irritability of temper, while fits are not uncommon.

Treatment. (*a*) **Prophylactic.**—The deformities can be prevented by early and persistent treatment by manipulation and mechanical support designed to stretch the shortened and contracted muscles and to counteract the force of gravity, thus relieving the weaker muscles of overstretching and secondary loss of function. For instance, when talipes equinus is threatening it can be prevented by repeatedly pressing up the fore part of the foot and maintaining the corrected position by means of a simple night-splint. Massage and exercises which are designed to strengthen the weak muscles are especially valuable. A great deal of care is also necessary in educating these children in the arts of standing and walking to the best advantage; this education to develop the peripheral muscle-balance, and open up other cerebral tracts to regain co-ordination, is at once the most important, the most protracted, and the most difficult part of the treatment. Mental deficiency increases the difficulty, but the mental condition improves together with the physical.

(*b*) **Operative.**—Operative treatment has proceeded along three lines. The oldest method, still largely used, is that of tenotomy and division of muscles. The groups which overact and give most inconvenience are—in [illegible]

only corrects the contractures, but leaves the corresponding muscles permanently weakened, which is an advantage. Some years ago, posterior nerve-root section (Förster) was extensively tried, with the object of diminishing the spinal reflex activity by attacking the sensory side; this led to no great results and has been practically abandoned in this country. More recently Stoffel has advocated section of some of the motor tracts in the larger peripheral nerves. This method, or its modification, excision of a proportion of the nerve branches to the individual overacting muscles, has the object of diminishing the degree of the reflex or voluntary motor stimulus. All these methods have as their aim the greater equalization of the muscle pulls on opposite sides of the joint. Other methods, such as tendon and muscle transplantation and arthrodesis, so serviceable in spinal paralyses, are of very little use in spastic paralyses.

In those deformities of the *lower extremity* where the posterior muscles are shortened to such an extent as to prevent passive dorsiflexion of the ankle well beyond the right angle, tenotomy of the tendo Achillis is advisable. If this is too long deferred the equinus will gradually increase. Secondary deformities appear, the anterior muscles get progressively weaker, and the bones of the tarsus become deformed. A moderate amount of equinus is often masked by secondary valgus. In some cases it is necessary to divide the tibialis posticus also; but this is to be avoided if possible, because it tends to increase the valgus. When the heel tendon is shortened more than 2 in., ordinary tenotomy may be followed by weak union and dropped heel or postoperative calcaneus, for which reason it is preferable to slit and lengthen the tendon, either subcutaneously, or through an open wound; in the latter case the tendon is sutured. In more

severe cases with secondary pes cavus it is necessary to correct the cavus, either by division of the plantar fascia or by the more radical operation of Steindler, and to lengthen the heel tendon. While the foot is kept in the corrected position, massage, movement, and exercises are adopted early in the after-treatment. The increase of
proceeds satisfactorily. In severe ca
to the knee and a T-valgus or T-va
necessary for about a year after the operation. A night-splint is required for a longer time. When the steel supports are no longer needed the slight shortening of the leg which is usually present can be corrected by means of cork concealed within the boot. In some cases it is necessary to divide the hamstring tendons to correct flexion of the knee-joint. This is best done through a long curved incision in the popliteal space Thus the tendons and the fascia can be completely divided and lengthened without any risk of injury to the popliteal nerves or blood-vessels. In many cases the adductor muscles need subcutaneous division or, in severer cases, resection of an inch or so of their upper ends (Robert Jones).

After operations upon the knees and hips the patient is confined to bed for three weeks to two months, during which period the thighs are kept widely abducted and the knees fully extended in some abduction splint, daily exercises and massage being carried out When walking is resumed, a temporary appliance may be necessary to maintain the extension of the knees and the abduction of the hips

Operations upon the arm are less satisfactory than those upon the leg, because of the more highly specialized function of the hand Much can be done, however, to correct deformity by exercise and voluntary efforts, combined with the use of a "cock-up" splint at night to keep the wrist and fingers extended; an extension of this splint to the upper arm, the elbow being kept at a right angle, will maintain supination of the forearm. Tendon transplantation at the wrist, analogous to the method adopted in irrecoverable musculo-spiral paralysis, is not very satisfactory; but the

to assist supination.

The method of Stoffel may be applied to the arm and the leg. For strongly contracted and spasmodic thigh adductors, the obturator nerve

nerve is divided intrapelvically, before it enters the obturator
Internal rotation of the thigh may be overcome by division of the nerve branches to the gluteus medius and minimus. The nerve supply to the hamstrings (for correction of flexed knee) can be exposed behind in the upper part of the thigh, and that of the gastrocnemius and soleus (for correction of equinus) in the upper half of the calf All the nerve branches
are exposed and ¼ to ½ in. is excised from as many
The proportion of nerve
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as a rule too
ken. In the arm the same method is adopted to lessen pronation and finger flexion spasm. An incision is made over the median nerve at the bend of the elbow, and the branches to the pronator radii teres and sublimis digitorum are isolated; all those of the pronator are excised, and most of the supply of the sublimis. If the

thumb is tightly flexed, the supply to the flexor longus pollicis is dissected out, and a proportion of the branches removed. Neurectomy should be followed up with splintage, stretchings, active exercises and massage. The operations on the popliteal nerve for relief of equinus are usually successful, and obturator and gluteal neurectomy corrects the adductor and internal rotation spasm. The results of operation on the median nerve are more uncertain; contracture is undoubtedly lessened, but the functional improvement depends on the severity of the disease, the mentality of the patient, and the care and persistence of the after treatment.

DEFORMITIES DUE TO INFANTILE PARALYSIS (ANTERIOR POLIOMYELITIS)

Infantile paralysis is one of the commonest causes of acquired deformity, the prophylaxis and treatment of which form a large part of orthopædic surgery.

Definition and general description.—Infantile paralysis is due to a destructive inflammation in the anterior horns of the grey matter of the spinal cord. This leads to paralysis and atrophy of the muscles which receive their nerve supply from the affected part of the cord (Fig. 898), to deficiency of growth of the limbs, and to vaso-motor disturbances.



Fig. 898.—Anterior poliomyelitis: complete paralysis of lower limb. (*Ernst*)

Pathology. (*a*) **Etiology.**—This disease most frequently occurs in young children between 1 and 4 years of age, but occasionally it affects older children or even adults, the latter especially during epidemics. It is more common in the summer, and occurs sporadically or in mild epidemics in this country, though more severe epidemics have occurred in America and on the Continent. Various micro-organisms have been cultivated from the cerebro-spinal fluid and from the lesions in the cord, but no satisfactory evidence has been brought forward that these are causal. The disease is undoubtedly infective, and the infective agent may be found in the naso-pharynx of apparently healthy subjects (carriers). Flexner has shown that it is caused by a filter-passing virus and that the causal organism is probably ultramicroscopic.

(*b*) **Morbid anatomy.**—If death occurs soon after the onset of the disease, small hæmorrhages and other signs of inflammation are seen in the

severe cases with secondary pes cavus it is necessary to correct the cavus, either by division of the *plantar fascia or by the* more radical operation of Steindler, and to lengthen the heel tendon. While the foot is kept in the corrected position, massage, movement, and exercises are adopted early in the after-treatment. The increase of power in the anterior group of muscles proceeds satisfactorily In severe cases a double steel support extending to the knee and a T-valgus or T-varus strap and a toe-lifting *spring are* necessary for about a year after the operation. A night-splint is required for a longer time. When the steel supports are no longer needed the slight *shortening of the leg which is usually present can* be corrected by means of cork concealed within the boot. In some cases it is necessary to divide the hamstring tendons to correct flexion of the knee-joint. This is best done through a long curved incision in the popliteal space. Thus the tendons and the fascia can be completely divided and lengthened without any risk of injury to the popliteal nerves or blood-vessels. In many cases the adductor muscles need subcutaneous division or, in severer cases, resection of an inch or so of their upper ends (Robert Jones)

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The method of Stoffel may be applied to the arm and the leg. For strongly *contracted and spasmodic thigh adductors, the obturator nerve* [illegible] enters the thigh, [illegible]

branches to the gluteus medius and minimus. The nerve supply to [illegible] hamstrings (for correction of flexed knee) can be exposed behind in the upper part of the thigh, and that of the gastrocnemius and soleus (for correction of equinus) in the upper half of the calf. All the nerve branches to the individual muscles are exposed and ½ to ¾ in. is excised from as many *of these branches as is considered necessary.* The proportion of nerve supply to be sacrificed will depend on the relative spasticity of the muscles; as a rule too little rather than too much is taken. In the arm the same method is adopted *to lessen pronation and finger flexion spasm.* An incision is made over the median nerve at the bend of the elbow, and the branches to the pronator radii teres and sublimis digitorum are isolated; all those of the pronator are excised, and most of the supply of the sublimis. *If the*

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Fig. 899.—Infantile paralysis with flexion-contracture of left knee and foot and equinus deformity. (*Ernst*)

Symptoms and signs.—The onset is usually quite sudden, the disease coming on as a febrile *attack which is fol*lowed by paralysis within three or four days. In other cases the child goes to bed quite well and is found to be paralysed in the morning. Occasionally vomiting and convulsions occur, and are shortly followed by paralysis. During the first fortnight pain and tenderness occur in *the limbs; this usually* passes off at the end of a fortnight, but in some cases lasts a month or more. The paralysis may be very extensive, but within two or three months many of the affected muscles may recover either partly or completely. At first the recovery may be rapid and striking, but it is rarely complete, and very little, if any, improvement occurs after two years in cases which have been properly treated. *Muscles which are not* paralysed may, however, be ingeniously used to do some of the work of those which are para-

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cold weather and from the pressure of splints upon the calf. The foot is often blue and cold from vaso motor paralysis. In severe cases the tendon reflexes are diminished or lost. Anæsthesia is not uncommon in the very early stages of the disease, but it soon disappears; and the same is true of loss of power of the sphincters. In the course of time, unless guarded [illegible] mechanical effects [illegible] within wide limits. There may be complete paraplegia or only loss of power of one or two muscles of the arm or leg. The paralyses and deformities are rarely equal or symmetrical in the affected limbs. Obvious lesions of the muscles of the trunk and head and neck are relatively rare, but lateral curvature may result from involvement of the spinal and abdominal muscles, or from inequalities in the length or power of the limbs. The lower limbs are far more often affected

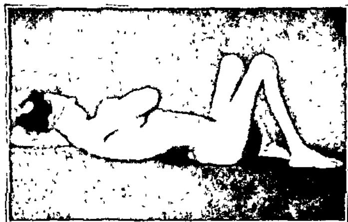


Fig. 900.—Contractures due to infantile paralysis.

than the upper. Of the muscles of the *lower limbs* the peronei and the extensors of the toes and the dorsiflexors of the ankle, especially the tibialis anticus, are the most frequently affected. The tibialis posticus and the calf muscles are less commonly involved. The small muscles of the foot are often, but less obviously, paralysed. The quadriceps extensor is very often weak or quite paralysed, and the hamstrings less frequently. The sartorius and the ilio-psoas are very rarely paralysed. A method of detecting paralysis of the ilio-psoas muscle has been pointed out by Ludloff. If the patient be sitting upright on a table it will be found that he is unable to raise the thigh if the ilio-psoas is paralysed, as in that position the other flexors of the hip—sartorius, rectus, and tensor fasciæ femoris—are thrown out of action. With extensive paralysis the knee and hip may be flexed, and the latter abducted. (Fig. 900.) Of the muscles of the *upper limb*, the deltoid and the muscles of the scapula are the most commonly affected. The biceps and supinators are often involved. The flexors and extensors of the hand and wrist are sometimes involved, and drop-wrist may then result. Sometimes the whole of the upper limb may be paralysed, when the shoulder, the elbow, and the wrist-joints become quite flail.

The commonest deformities of the *lower limb* are talipes equino-varus,

affected parts of the cord. In later cases there is some shrivelling of the anterior part of the cord; many of the anterior horn cells are missing or atrophic, and the anterior nerve-roots are *atrophied*. The paralysed muscles are wasted, and frequently infiltrated with fat. The bones and all the other structures of the affected part are also weak and atrophied.



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cold weather and from the pressure of splints upon the calf. *The foot is* often blue and cold from vaso-motor paralysis. In severe cases the tendon reflexes are diminished or lost. Anæsthesia is not uncommon in the very early stages of the disease, *but it soon disappears, and the same is true* of loss of power of the sphincters. In the course of time, unless guarded against, deformities develop as a result of gravity and the mechanical effects *of misguided efforts at progression.*

The extent and distribution of the paralysis vary within wide limits. There may be complete paraplegia or only loss of power of one or two muscles of the arm or leg. The paralyses and deformities are rarely equal or symmetrical in the affected limbs Obvious lesions of the muscles of the trunk and head and neck are relatively rare, but lateral curvature may result from involvement of the spinal and abdominal muscles, or from inequalities in the length or power of the limbs The lower limbs are far more often affected

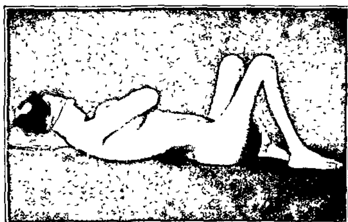


Fig. 900 —Contractures due to infantile paralysis.

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The commonest deformities of the *lower limb* are talipes equino-varus,

equino-valgus, and calcaneo-valgus, flexed knee, and abduction-flexion contracture of the hip.

Diagnosis.—Infantile paralysis is usually so characteristic that it is difficult to make a mistake in diagnosis except in the very early stages of the disease, before paralysis is well developed. The pain and tenderness of a limb which often precede the paralysis have sometimes led, especially when

from other kinds of paralysis and deformities.

The capricious and asymmetrical distribution of the lesions of infantile

diagnosis. It is particularly important to distinguish talipes due to *infantile paralysis from the varieties due to (a) lesions of the upper neurone,* (b) other lesions of the lower neurone, (c) primary muscular disease (muscular dystrophy).

(a) In talipes due to *destruction of the upper neurone*, such as cerebral paralysis, the reflexes are exaggerated and the plantar reflex is extensor, whereas in talipes due to disease of the lower neurone the reflexes are unchanged, diminished, or lost. *Reaction of degeneration is present in lesions* of the lower neurone, and absent in lesions of the upper. Coldness and blueness of the feet are only comr

the same is true of trophic ulcers

much greater in lesions of the lov

plegia. In any case the deformity due to *disease of the upper neurone is* almost characteristic and is mostly equinus, usually with a little varus, but occasionally with slight valgus, whereas in lesions of the lower neurone

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ar or more after birth, but it is usually

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spastic

paraplegia.

wasting of the upp

occasional cause of talipes equinus or equino-varus; it can be recognized

by the inco-ordination, the loss of both knee-jerks, the nystagmus, the slurring of speech, and late onset.

(*b*) *Lesions of the lower neurone* may be in the cord (infantile paralysis), in the cauda equina (spina bifida), in the lumbo-sacral cord or sacral plexus, or in the peripheral nerves (peripheral neuritis, injured sciatic nerve, and Tooth's neuro-muscular paralysis). Infantile paralysis is, as already pointed out, distinguished by irregular distribution and reaction of degeneration, with vaso-motor and trophic lesions. It is frequently possible to show that the

is not necessarily symmetrical; one foot may be involved more than another, and the deformity is often progressive. Wounds of the thigh, or the pressure of tight splints in the treatment of fracture, or the forcible extension of a contracted knee, may lead to paralysis of the sciatic nerve, especially of its external popliteal branch; this may produce talipes equino-varus A similar deformity may follow injury of the lumbar spine with secondary hæmatorrhachis or growth anywhere in the course of the sciatic nerve. Tooth's neuromuscular paralysis causes paresis of the anterior tibial and peroneal muscles, with talipes equino-varus and marked cavus, and deformity of the toes. It may be distinguished from infantile paralysis by the later onset, the symmetrical affection of both feet, the wasting of the thenar eminences, and the family history of similar deformities.

(*c*) In *primary muscular paralysis* talipes may slowly develop late in the disease; but, as a rule, these patients do not live long enough for the deformity to become a striking feature of their condition. The cause is usually recognized from the family and early history, the affection of the spinal and scapular muscles, and the characteristic way in which the patient raises himself from the ground by rolling into the prone position and then lifting himself on his toes and hands and placing a hand upon the front of the thigh.

There is usually no difficulty in distinguishing talipes due to infantile paralysis from congenital club-foot (*see* p. 1028).

In infantile paralysis the diagnosis is not complete until the paralysed or weak muscles have been identified, because a knowledge of their condition is of vital importance in treatment. The best way to obtain this informa-

degeneration. If a muscle can be shown to be capable of voluntary contraction it may be possible to increase its power very considerably by suitable treatment. Moreover, if the balance of power around the joint is not good, some part or the whole of the tendon of a powerful muscle may be diverted to assist the weaker ones.

Treatment.—The prevalent treatment of infantile paralysis is not always satisfactory, for several reasons. It calls for a great deal of care extending over a long time Deformities develop so insidiously that they may appear to be inevitable, whereas they are mostly preventable. The value and importance of suitable instruments designed to prevent these contractures are not sufficiently recognized, and there is a current idea that

instruments of all kinds do not aid but hinder the restoration of function. The advantages of well-planned exercises are little understood, whereas much faith is placed in massage and electricity, which are comparatively useless. The parents expect quick results, get tired of tedious methods and discontinue them. The value of timely operations designed for the restoration of the balance of power around joints and for the firm support and equilibrium of the body is not yet thoroughly appreciated It is, therefore, common to see patients whose condition could have been much improved by rational treatment at an earlier date. Much can be done to prevent contractures even in extreme cases of infantile paralysis. It is most necessary to do this, the deformities being not only disabling in themselves, but also interfering with the nutrition and development of any muscles that may have escaped complete paralysis. The stretching of weak muscles and the contracture of their stronger antagonists lead to progressive weakening of both, whereas a free range of movement is essential to the healthy circulation and growth of all muscles It is obvious that the action of muscles must be imperfect when the joints and bones upon which they act have lost their natural mobility and shape. It is of vital importance, therefore, to prevent contractures (and incidentally to avoid the need of operations to correct them), whenever possible.

is at its worst when first detected (usually two or three days after the onset of the acute illness), and not much recovery will be obvious for the first month or so. The second is the ambulatory or convalescent stage, lasting to the end of the second year, and is the period in which spontaneous

it is impossible at first to decide the fate of the muscles. Some of the anterior horn cells will have been destroyed completely, while others will be only temporarily disabled As it is impossible to say where most damage has occurred, all the muscles must be treated alike for a time. Rest is necessary, both for the spinal cord and the paralysed muscles. As soon as the acute condition will permit, correct positions of the joints must be maintained, to ... patient should lie flat on the ... eral curvature of the spine; to prevent than to cure. It bed, therefore any tendency xing the patient in a plaster-position. Spinal curvature may also result from unequal involvement of the trunk or limb muscles on the two sides; or may follow general, but not unequal, involvement of the spinal muscles, which are weak when the child first begins to sit up; in such a case transition from the recumbent to the ambulatory stage should be most gradual, with due regard to the protection of the spine and the prevention of an avoidable curvature. To preserve the deltoid and the biceps, which are very prone to remain paralysed when the arm is affected, the upper arm must be kept abducted, with the elbow at the level of the shoulder and flexed to a right angle, the forearm supinated, and the wrist dorsiflexed. This position can be maintained by bandages, sandbags, pillows, or light

abduction splints when the patient sits or stands. Foot-drop must be prevented from the first, by splints keeping the foot at right angles to the leg; the knees should be kept fully extended, to favour the recovery of the quadriceps. The quadriceps is to be favoured rather than the hamstrings, as it is more liable to remain permanently paralysed. The adductors and extensors (glutei) are more susceptible to damage than the flexors and abductors, and so the hip-joints are to be kept extended, with the thighs close together. The feet should be pointed vertically upwards to favour the internal rotators of the hips.

Gentle massage may be given when the pain has disappeared; but massage is likely to irritate the spinal cord and is contra-indicated if it causes pain or if tenderness exists. Any deformity that may have occurred can easily be corrected by gentle passive stretchings of the contracted muscles, assisted by the splints. Close observation must be kept on the muscles, the weakest being held relaxed and shortened by the splints, and those that are beginning to act stimulated by the gentlest of assisted active exercises. Electrical treatment is of no use in the early stage.

Second stage.—The second stage extends over the two years succeeding the acute period spent in bed; the treatment should be essentially physico-therapeutic, instrumental, and re-educative The various possible deformities must be carefully prevented, and only the simplest operations, such as tenotomy, division of contracted fasciæ, and forcible manipulations should be undertaken, to correct such deformity as has occurred. As soon

that has been well treated throughout, must be regarded as hopeless Muscles which show no signs of recovery for many months are not likely ever to develop very much (Fairbank) The recovery of power in a feebly

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would yield under the influence of gravity, and cause the patient to fall; the weakest joint is to be splinted first. Only one ankle or one knee may require support, or the whole of one leg, or, perhaps, both legs and the thighs In extensive cases, sticks or walking frames may be required, but crutches are best avoided if the patient can possibly balance without them Not only by day with appliances, but at night also, with lighter splints, adequate support must be given to prevent overstretching of the paralysed muscles and the deforming effects of position and gravity. When the splints are changed or are removed for treatment, the limb must not be allowed to fall into such positions as would overstretch the paralysed muscles The limbs must be warmly clad, and the splints and straps must *not compress* the muscles or restrict the circulation.

Massage and exercise treatment must continue steadily throughout the second stage. The rubbing must be gentle, as heavy massage is damaging to paralysed muscles. Any tendency to deformity in any one direction is to be corrected by regular and vigorous passive stretching of the muscles

which tend to retract; and the weakened antagonists should be developed as far as possible by active movements. Active exercises are the best means of increasing the power of a weakened muscle, provided it has sufficient strength to make some sort of voluntary contraction. But *the work imposed* on the feeble muscles must be carefully graduated, and proportioned to their power; the masseuse provides for this in her assisted exercises. To

are the next best measures, but are not nearly so efficacious as active exercises; electrical treatment in children may be impossible. The physicotherapeutic measures, besides developing the muscles, are of importance in assisting the circulation and growth of the limbs.

In the production of deformity—from gravity and insufficiency of the paralysed group—the healthy antagonists become shortened by the contracture of the fibrous sheath of the muscle. A completely paralysed muscle does not usually become contracted. Occasionally one muscle about a joint will recover alone and constitute a considerable deforming factor, as in the case of the biceps cruris producing at the same time flexion, external rotation, and genu valgum at the knee-joint. Unfortunately deformity frequently occurs in spite of the best of care; this must be corrected before the patient can get about properly in appliances. *It is bound to get worse if neglected*, and, while it exists, muscles that might recover are prevented, by overstretching, from so doing.

gradual daily passive stretchings, combined with fixation in plaster of paris *or removable splints. The tendo Achillis is now usually tenotomized* by the Z-shaped lengthening method of Bayer; but when the shortening is considerable, it is safer to lengthen and suture the tendon through an open incision, otherwise it might heal thinly and poorly, or even remain ununited. After the operation, the foot and leg should be fixed in plaster of paris for ... not be made ... is the thickened ... excised, and the ... od of Steindler ... y divided subcutaneously just above the external malleolus; but division of the external lateral ligament of the ankle, *and lengthening of the tibiales anticus* and posticus tendons, are better done through an open incision. Contracted extensor tendons of the toes heal well after subcutaneous tenotomy, but the flexors do not. The hamstring tendons are lengthened by open operation

than do the hamstring tendons. The shortened tensor fasciæ ... sartorius, causing the *very commonly occurring flexion-abduction-contracture* ... *anterior superior* ... n of the hip in a ... verted, adducted,

and extended, or alternatively by weight traction with the patient prone and the hip hyperextended. But a better method is that of detaching these muscles from the iliac bone through an open incision, if necessary dividing all muscular and fascial structures down to, and perhaps including the anterior part of the capsule of the hip-joint. Another radical method is that of Souter, who detaches the iliacus muscle from the fossa, and allows it to slip down.

When the back muscles are involved the onset of scoliosis must be averted by an efficient spinal appliance, which, taking a bearing from the pelvis, vertically extends the spine by axillary crutches attached to the back steels, the front of the chest being left quite free, for unhampered respiration, but the lower abdomen well supported. If curvature has already occurred, a moulded leather or celluloid jacket should hold the spine and trunk in an overcorrected position. For night use a plaster bed must be employed, local corrective pressure being applied by webbing straps across the convexities or by felt pads.

Appliances—The walking appliance commonly used for the legs is the calliper splint, which, fitted with straps, prevents the knee from flexing and the ankle from yielding laterally. A toe- or heel-raising spring may be attached if the dorsiflexors or the calf muscles are deficient, extension slides allow for growth, and where economy is a consideration knee- and ankle-joints may be dispensed with. It is important to remember that a paralytic knee s[illegible]
extension, as thereby the joint may
the necessity for an appliance bey
With the least flexion-contracture of the knee and deficient power in the quadriceps, the patient will inevitably fall unless the instrument extends to the groin. For paralysis involving the leg below the knee only, single or bilateral steels attached to a calf band just below the knee, combined with the requisite ankle straps and toe- or heel-raising springs, will suffice. The inner tibial muscles or the outer peronei may be assisted by thickening the sole and heel of the boot to the extent of a quarter of an inch, on the inner or outer borders respectively. A short leg will require a patten, a thickened cork sole, or the more cosmetic O'Connor boot—in which the shortening is compensated by thrusting the foot into an equinus position. For night use a light metal or celluloid splint may be arranged to keep the knee quite straight, and the foot in the equinus, calcaneus, varus, or valgus position, as necessary. The "cock-up" splint is used for the wrist. For paralysis of the deltoid, use is made, at least in the early stages, of the light metal abduction splint devised by Fairbank for similar treatment of cases of Erb's paralysis

Third stage.—When no further increase of power is possible in the weakened or paralysed muscles, the various reconstructive surgical operations are indicated. Their objects are to restore or increase the power of movement in a certain direction—a redistribution about a joint of what power is left, so as to effect a more even balance; to increase stability of a joint; to check [illegible]
the need for app
enough residual
to permit some
or the operative
remains for distribution by tendon transplantation. A joint flaccid and flail from want of muscular control is worse than useless, and is a weak link in the chain of rigid joints necessary to allow a muscular action of the

hand or foot. A joint must therefore be capable of being fixed, and if this is not effected by an operation it must be done by splinting. In joints closely associated—for example, the ankle and subastragaloid joints—*arthrodesis and tendon transplantation* may be combined, the one joint being ankylosed, while the more important joint is given the assistance of all the available acting tendons. *Tenodesis* is a method of making a flail

tendons about

l. ligaments; at

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to dislocation,

reconstruction by grafting the acetabulum may afford the requisite stability.

A few general principles in *tendon transplantation* must be considered The deformity must previously have been completely corrected. Only those tendons whose muscles show considerable recovery should be transplanted. It must be possible to re-educate the transplanted muscle to perform its new function. *The most successful result occurs when a single tendon replaces* one of its own group, e.g. in transplantation of the tibialis anticus to act as the peroneus tertius When muscles are required to replace those of a different action, they should be transplanted in groups rather than singly —e g. all the hamstring tendons (with the exception of the semimembranosus) should be transferred to the patella, to act as extensors of the knee-joint, rather than the biceps alone The new path of the tendon is preferably *through the fatty subcutaneous tissue. It is better to attach the distal end* of the shifted tendon subperiosteally at its new site, or through a tunnel in the bone, rather than to suture it to another tendon. But the writer never hesitates to adopt the latter method, if necessary, and prefers to do

the early stage of re-education some further slight protection and assistance from splints and appliances is advantageous.

The transference of the biceps (Fig. 901), gracilis, sartorius, and semiten-

the slot-margins. Undoubtedly in poliomyelitis, and probably also in spastic paralysis, these quondam flexors of the knee can be re-educated in a few months to assume a pure extensor action, occurring synergically with any

The knee-joint must

With tendons sutured

rs only slowly, but it

omplete. The tensor

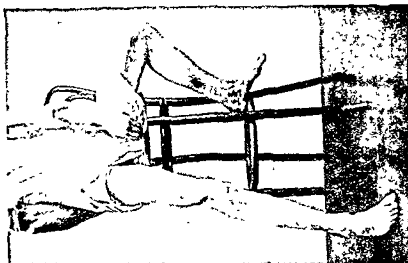
fasciæ femoris has been used to augment extension of the hip in paralysis of the glutei, but the transferable power is so inadequate as to make this operation scarcely worth while. The most effective transplantation in the foot is that of the tibialis anticus to the outer side, in cases of deficient eversion power from paralysis of the peronei, *the tendon being inserted into the* base of the fifth metatarsal or, failing this, into the tendon of the peroneus brevis at its insertion, or into the cuboid. The muscle is still a dorsiflexor,

but an abductor instead of an adductor; since, however, the tibialis anticus is inhibited in plantar flexion, as when standing on the toes, the peronei

the tendo

n—trans-

the foot,



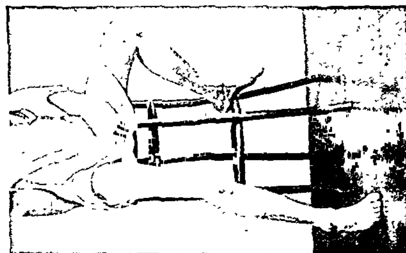


Fig. 901.—Transplantation of biceps for flaccid paralysis of quadriceps. 1, at rest; 2, contracted.

to replace a paralysed tibialis anticus—is usually a failure; any apparent success is due to a loss on the peroneal side rather than to a gain on the tibial Re-education is slow, as the peronei are plantar flexors, and their movements are naturally inhibited when active dorsiflexion, an action of the tibialis anticus, is attempted. Even when educated as a dorsiflexor, the peroneus has a new line of action so oblique that, in addition to dorsiflexion, it can

act only as an abductor, and not as an adductor as does the tibialis anticus. Both the peronei, brevis and longus, may be transferred to the cuneiform or scaphoid, at times together with the extensor proprius hallucis. In paralysis of the tibialis anticus, to procure inversion as well as dorsiflexion, the author prefers to insert the tendon of the stronger peroneal muscle, longus or brevis, into the distal long extensor tendons of all five toes, the suture being made just above the annular ligament; the proximal tendons of the healthy extensor communis digitorum and extensor proprius hallucis are then inserted into the paralysed tendon of the tibialis anticus. This line [illegible]

[illegible]

it is usual to take the stronger peroneus and the two long flexor tendons of the toes, and transplant them under tension through a vertical hole drilled in the os calcis immediately in front of the insertion of the tendo Achillis, which is shortened as much as possible at the time to act as a temporary suspensory ligament while the transferred tendons are being firmly incorporated. The associated secondary cavus deformity may be corrected at the same time, but this has a tendency to lessen gradually of itself in the [illegible]

[illegible]

tive to this "three-tendon" operation some surgeons prefer tenodesis, and others Whitman's astragalectomy (*see* p. 1069). For a "claw" deformity of the toes, associated with pes cavus, the long extensors may be detached from the toes and inserted into the metatarsals immediately behind their [illegible] he neck of the bones. The [illegible] but is tedious when appli[illegible] perextension at the meta[illegible] phalanges to become still more flexed, which is not an advantage. The overextending action of the long extensor tendons of the toes is transferred to the metatarsus, where it has a more direct effect in counteracting the cavus deformity. Hibbs modifies the operation by inserting the tendons of the extensor communis digitorum into the cuboid or the base of the fifth metatarsal bone. The author prefers to correct claw deformity of the toes by detaching the long flexor tendons from their insertions into the terminal phalanges [illegible]

[illegible]

new function of the transplanted long flexor tendons is now similar to that of the interossei. This operation may be employed for correcting hammer-toes if the flexor aspect of the capsule of the deformed interphalangeal joint be freely divided at the same time.

Transplantation operations for paralysis of the arm are not often done. Deficiency of the dorsiflexors of the wrist and extensors of the fingers may, with the existence of good flexors, be treated by the method used for irrecoverable musculo-spiral paralysis—the utilization of the flexores carpi radialis and ulnaris and the palmaris longus as extensors. For deficient power of opposition in the thumb, Ney has proposed to graft the healthy tendon of the extensor brevis pollicis into the flexor carpi radialis tendon, or into that of the palmaris longus. Attempts have been made to utilize portions of a healthy pectoralis major to replace a paralysed deltoid.

Arthrodesis must not be done before a patient is 10 years of age, and is better postponed until the age of 12 or later. The articular cartilage is removed and the cancellous tissue exposed, and osseous ankylosis is aimed at. In very young children the proportion of articular cartilage to actual bone substance is very considerable, and therefore the excision would need to be very extensive to approximate raw bone to raw bone Again, the reparative tendency in children is towards the production of mobility rather than ankylosis, and towards fibrous rather than bony union. Relapse would therefore be very liable to occur, and the fibrous ankylosis resulting might make the deformity more pronounced and more difficult of future treatment. After the operation, prolonged fixation in plaster for three months or more

be allowed to act until it is

Sometimes security is guaran-

he insertion of a bone-graft

d to the other Wires and

screws for this purpose are objectionable. The application of the arthrodesis method is most useful in the shoulder and foot. In the former, arthrodesis

be required The joint is ankylosed with the upper arm abducted about 60° from the side, and with the hand opposite the face; rotation of the scapula will permit further abduction or adduction from this position. In

...ve, if possible, the movements in the ankle-joint itself The lateral movements in a foot can be sacrificed with less inconvenience than the antero-posterior. It may be possible by tendon transplantation to use unparalysed muscles normally producing lateral movements, e g. the tibialis posticus, as reinforcements for the antero-posterior action of the ankle-joint. Naughton Dunn, in the operation he has described, thus utilizes all available power to strengthen plantar flexion and dorsiflexion in the ankle-joint, while sacrificing the lateral movements in the subastragaloid and midtarsal joints In his operation the lower part of the head of the astragalus, the upper part of the three cuneiforms, and the scaphoid are removed. The foot is displaced backwards at the time the subastragaloid joint is destroyed, until the remainder of the astragaloid head is superimposed on the residue of the cuneiforms. This backward displacement of the foot is a means of increasing the stability, and was advocated by Whitman in his *astragalectomy*, designed for paralytic calcaneus deformity but also utilized by others for stabilizing other types of paralytic feet. The astragalectomy method, although stiffening the foot, does not make it quite so rigid as a pure ankylosing operation; a very slight but serviceable movement may occur in the new joint formed between the tibio-fibular mortise and the scapho-cuboid region. If the peronei are acting, Whitman inserts them into the os calcis or tendo Achillis; if varus results from activity of the tibialis posticus or of the toe flexors, these may also be transplanted accordingly. Astragalectomy is of no use in a foot laterally unstable from the paralysis of one single muscle group, but is a good stabilizing operation for feet ...

or

hi

would sooner wear an appliance than have a rigid straight leg

The methods of *tendon fixation* (*tenodesis*) and of *artificial ligament-formation* are occasionally employed to prevent either toe- or heel-drop. The paralysed tendons are cut across and their distal ends are inserted and sutured under tension into a hole drilled in the tibia one or two inches above the ankle-joint. These new ligaments made from old tendons are very liable to stretch in time, allowing the deformity to recur. The method is of more use when combined with tendon transplantation in selected cases. For calcaneus the tendo Achillis is used, and for equinus the tibialis anticus and other dorsiflexors

The radical operations for stabilizing the spine in paralytic scoliosis are discussed in the section on Bone-grafting (p. 1124).

TORTICOLLIS (WRY-NECK)

Torticollis is a deformity of the neck, producing deviation of the head from the middle line, and also rotation. It is usually due to permanent shortening or to spasmodic contraction of the muscles on one side—often the sterno-mastoid, but occasionally other muscles as well—and thus may be met with either as a chronic painless fixed deformity, or as an acute condition which may be temporary, or may give rise to a fixed deformity. In the *acute* form the muscles on one side of the neck may be tonically contracted from inflammation of the muscles themselves or irritation of their nerves, especially the spinal accessory Such irritation may be due to cervical adenitis or to other inflammatory affections of the neck. A similar spasm occasionally occurs in hysteria. In *chronic* torticollis there is a real shortening of the sterno-mastoid; in severe cases the trapezius, splenius, and other muscles, and the cervical fasciæ, all show real shortening, and the spine is also deformed. The clinical condition may therefore result from many different causes, and the chief types met with are—

Congenital, of intra-uterine origin.
Resulting from trauma at birth, especially in breech presentation.
Acute spastic type, due to irritation and tonic contraction of muscle, from (1) injury or strain, (2) inflammation; (3) nerve-irritation.
Due to tuberculous disease of the cervical vertebræ.
Due to spinal curvature—cervical scoliosis
Spasmodic torticollis.
Due to scars, burns, and chronic sinuses.
Ocular torticollis, from unequal vision.
Paralytic, from infantile paralysis, diphtheria, cerebro-spinal meningitis.
Hysterical

Chronic Torticollis

Chronic torticollis is sometimes classified as *congenital* and *acquired*. Opinions vary as to whether the common type of fixed painless deformity

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of these cases as of intra-uterine origin.

ing shoulder may be elevated in late cases. The face is turned towards the opposite side, the chin being tilted upwards and pointing towards the opposite clavicle. The movements of the head and neck are limited, so that the patient has to move his body when he wishes to look towards the affected side When any attempt is made to correct the deformity the affected sterno-mastoid stands out prominently under the skin, and when measured it is found to be shorter than its fellow, the difference varying from ½ in to 2–3 in. The trapezius may also be prominent. The cervical spine is curved laterally with a convexity towards the opposite side. There may also be a small curve in the dorsal region in severe cases. In neglected cases the face is asymmetrical, being much smaller and shorter on the side of the affected muscle. This has been held probably to indicate the congenital nature of the deformity, but it is secondary to the malposition of the neck. The patient is not usually brought for treatment until the condition has existed for some years The history is often very vague, but it is hardly ever stated that the condition was noticed immediately after birth. There may be a history of difficult labour, and not uncommonly of breech presentation In some cases there is a definite history of hæmatoma of the sterno-mastoid As the child grows the condition becomes more severe and noticeable.



Fig. 902.—Torticollis.

Diagnosis and prognosis.—The common form of chronic torticollis differs from that associated with *caries of the cervical spine* in being painless, and in showing no evidence of bone disease in the skiagram. Unlike caries, when the muscle is relaxed rotation is quite free and painless In caries all the muscles of the neck are spasmodically contracted; both pain and spasm are increased by any attempt at rotation. In wry-neck the chin is tilted away from the concave side of the neck, whereas in caries it is usually turned towards that side. The condition is distinguished from *hysterical* wry-neck by the history and by the effect of steady traction, which gradually overcomes hysterical spasm. *Acute* wry-neck may be recognized by its sudden onset and short duration. When the contracted muscle is relaxed, enlarged glands can generally be felt beneath the upper part of the affected

sterno-mastoid. In early cases the prognosis after operation is good, but in late cases, with secondary deformities of the face and cervical spine, recovery is rarely complete.

Treatment.—If taken early, the slighter cases of congenital and acquired wry-neck can be corrected by manipulation. While the shoulder of the affected side is fixed, the neck is fully extended in length by traction and the head is gradually and firmly brought into the overcorrected position. It is drawn towards the opposite side and backwards, and at the same time rotated until the chin is above the same shoulder, so as to stretch the sterno-mastoid and other contracted tissues to the full extent. These manipulations should be carried out daily and combined with massage of the contracted tissues. In most cases, however, the deformity is so great as to demand operation. The contracted sterno-mastoid must be divided, and in some cases the trapezius and the deep cervical fasciæ also.

(1) *Subcutaneous tenotomy is suitable only for milder cases in which the* affected sterno-mastoid is not more than 1 in. shorter than its fellow, and when the shortening is limited to the sternal tendon. It has the merit of not leaving any scar The sternal tendon is *stretched by placing a sand*-pillow under the shoulders and exerting traction on the neck. A tenotome is inserted immediately behind the tendon, which is divided from behind forwards. If the tenotome is introduced as low down as possible there is little or no fear of wounding the internal jugular vein.

(2) *The open method*.—When the clavicular head of the muscle and the fasciæ have also to be divided it is safer to do an open operation. The wound may be made either parallel to or across the lower part of the contracted muscle. The former gives better access, but the latter, when curved and ... The sternal tendon

the other structures stretched by forcible manipulations. In some cases it *is necessary to divide the trapezius subcutaneously near the occiput under* cover of the hair. The wound is accurately closed, and covered with an abundance of dressings, which are firmly applied to prevent oozing. *A massive dressing has the further advantage of keeping* the head in the overcorrected position. There is rarely need for the plaster splint which is sometimes used The patient is encouraged to move the head after the fourth day, and passive movements are commenced at this time. The patient is usually confined to bed for about ten or fourteen days, after which he is allowed to get about with the neck supported for a week or two by a bulky wool dressing. If the deformity has been severe, a "torticollis sling," maintaining overcorrection, may be advisable for a month or so. Passive stretchings and active exercises are continued daily until the muscular power and the full range of voluntary movement are restored.

(3) *Lengthening the sterno-mastoid*.—Complete division of both the sternal and clavicular origins is liable to result in a gap in the muscle, causing *asymmetry of the lower part of the neck.* To obviate this Rowlands advises ... the sterno-mastoid instead of merely dividing it, maintaining

...onspicuous

The sternal

...d the cleft

between the two heads is extended upwards to the required degree. The clavicular belly is isolated at the upper end of the wound and divided obliquely upwards and backwards, well below the spinal accessory nerve. *All shortened*

fasciæ are divided, and the deformity is overcorrected by manipulation. Bleeding having been arrested, the two heads of the muscle are joined with fine catgut. The sutured muscle should be long enough to lie slack in the wound when the head is in the overcorrected position. After any of these operations, the younger the child the more perfect will be the result attained, and the less the need for after-treatment. In late cases bony and ligamentous changes in the cervical spine tend to prevent a perfect result, and the fascial hemiatrophy is permanent; in these, too, the fibres of the shortened muscle have become atrophied from the long-continued contracture.

Acute Torticollis

In this condition the muscles on one side of the neck, especially the sterno-mastoid, are in a condition of tonic spasm. This may be due to a variety of causes, the most important of which is inflammation of the cervical glands in the neighbourhood of the spinal accessory nerve in the upper part of its course and deep in the neck. It may be also a reflex spasm due to irritation of the sensory nerves in the ear, throat, nose, or teeth. It can occur from hysteria. Wry-neck sometimes develops as a result of injury or strain of the muscles of the neck. A similar distortion occurs after exposure, and is commonly described as a cold, or muscular rheumatism. The affected muscles are tender and contracted. When the deep cervical glands suppurate, real contraction of the cervical fasciæ may occur, and secondary actual shortening of the sterno-mastoid. The head is held in the characteristic position already described under Chronic Torticollis On careful examination, enlarged lymphatic glands may be felt under the upper part of the sterno-mastoid, or sinuses may be seen discharging in the neck. Any attempt to correct the deformity is painful. There is a history of sudden onset, and often of an inflammatory condition in the throat or ear.

Diagnosis.—It is very important to distinguish this condition from wry-neck due to *caries of the spine*. In caries all the muscles of the neck spasmodically contract upon any attempt to move the head, whereas in acute spastic wry-neck the muscles on one side only are affected, and when these are relaxed passive rotation is painless. Moreover, pressure on the head gives rise to pain in caries but not in acute wry-neck In caries there may be some grating upon rotation, and a skiagram will give evidence of tuberculous disease of the vertebræ. It is sometimes difficult to decide upon the exact cause of the chronic spasm of the sterno-mastoid. In examining for enlarged glands it is important to relax the affected sterno-mastoid by letting the patient lie down, when glands can often be discovered which are not distinguishable when the patient is in the upright position. In some cases of wry-neck following injury a fracture of one or more of the spinous processes of the vertebræ may be discovered by skiagraphic examination *Hysterical* wry-neck is recognized by the other symptoms of this disease which are usually present, and by the corrective effect of manipulation with or without an anæsthetic

Treatment.—The prognosis is good if proper treatment be adopted before the contracted muscles become shortened; otherwise the deformity may become permanent. The cause of the spasm must be removed if possible. When the lymphatic glands are enlarged the primary source of the sepsis should be dealt with, and when they are tuberculous it may be necessary to remove them in some cases. It is important to correct the deformity by rest in bed, and by the use of a suitable support or appliance.

Spasmodic Torticollis

This is an uncommon affection occurring in adult life. Spasmodic rotatory movements of the head take place during the day, but they entirely cease during sleep. The sterno-mastoid and the trapezius *on one side* are the chief and often the only muscles affected. The condition is due to some form of disorder of function of the cortical centres which control the movements of the head. No structural changes in the nervous system have been described. It is commonly seen in persons of a neurotic temperament and the subjects of overwork. Sometimes it develops suddenly as a result of severe mental shock. At first the affected muscles are only spasmodically contracted, but later on they may become shortened.

There is generally a history of gradual onset of a neuralgic pain in the head and neck, with slight twitchings. Gradually the twitchings and the pain become more severe. The movements are characteristic—jerky and rotatory—and are due to the interrupted contraction of the sterno-mastoid and trapezius on one side, while in some cases the complexus, splenius, and the oblique muscles of the opposite side also contract. In severe cases the spasmodic movements may spread to the muscles of the face and even to the chest. Apart from surgical treatment the prognosis is bad, but resection of the nerves of the affected muscles has resulted in a fair amount of success.

Treatment.—Medical and constitutional treatment is necessary. Massage and systematic exercises sometimes succeed. Mechanical supports are generally intolerable, but absolute fixation of the head and neck for a few weeks in a plaster-of-paris case, followed by a light supporting appliance, may afford considerable benefit. Resection of a portion of the spinal accessory nerve before it enters the sterno-mastoid has been successful in nearly half the cases When this operation fails the posterior divisions of the upper cervical nerves may be resected, and this on the whole has given good results. If the muscles have become shortened they also may require division Massage and active movements must be continued for some time after any operative treatment.

SCOLIOSIS (LATERAL CURVATURE OF THE SPINE)

D ... lateral

... in which the
... tissues and
the skeleton is as yet little advanced and offers little obstruction to treatment—the simple or reducible curve; and the *second* stage, the fixed, structural, or irreducible curve, which can no longer be corrected by passive or ... which supervened at first
... is now due to alteration
...

recognized, and measures taken to prevent it.

Scoliosis is actually a deformity of the trunk, in which the lateral deformity *of the spine is the most characteristic and intractable feature.* The associated asymmetry of the trunk may be quite out of proportion to the degree or fixity of the spinal deformity; there is no constant relation between the



Scoliosis.

PLATE 143

two Distortion of the trunk may occur not only in the lateral direction, but also in the antero-posterior, some cases showing considerable dorsal kyphosis and lumbar lordosis. In all but the very early stages, in addition to the *lateral inclination* from the middle line, there is *rotation* of the spine on its long axis



Fig. 903.—Severe scoliosis.

(Plate 143); the bodies of the vertebræ involved in the curve are deflected farther from the middle line than are their corresponding spinous processes and neural arches; thus, if it could be seen from the front the spine would appear more curved than when viewed from behind

Rotation implies structural alteration in the vertebræ, and denotes fixed deformity; it is due to torsion of the trunk, and is far more difficult to correct than ... gree ... with ... not

be associated with any appreciable rotation, while severe lateral deviation is always accompanied by rotation. Lateral deviation is usually more obvious than rotation. Rotation adds to the asymmetry of the trunk, by a backward projection at the level of the maximum curvature. This is most obvious in

and in the base of the neck in cervico-dorsal curves. Very rarely the vertebræ rotate in the direction opposite to the convexity of the lateral curve (*paradoxical rotation*); this denotes a transitional stage, in which a single

formation of a second curve (the secondary or compensatory curve) is a natural reaction in the attempt to maintain balance and restore the symmetry of the trunk. It may be impossible to correct a fixed single curve by treatment without causing a secondary curve, but this may be the best compromise. A third curve is a smaller compensatory curve at the other end of the primary curve. The primary and secondary curves may be equal or unequal in length, but if the primary is marked, the secondary will be also. When the scoliosis

A lowered pelvis (due to a short leg) is practically a curve concave on that side, while a raised pelvis (adducted hip) is a primary convexity. A total C-curve

C-curve convex to the left,

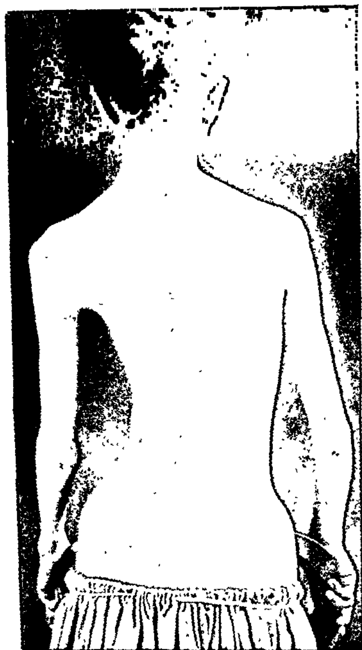
(constituting about three-quarters of the cases of fixed curves met with in adolescence and adult life), a *single dorso-lumbar curve to the left*; and a single dorso-lumbar to the right. The neck is not so commonly involved; a high dorsal curve may affect the lowest cervical vertebræ, and a neglected torticollis may produce a cervico-upper-dorsal curve on the opposite side.

lateral direction and this

its minimum, is the most potent in the production or furtherance of the formity. The normal lumbar antero-posterior concavity is diminished or obliterated, and the thoracic antero-posterior convexity is increased. If the sitting position is asymmetrical, the bodies of the vertebræ are induced to rotate in the direction of the lateral convexity. Therefore rotation may possibly occur early in the production of the deformity. Some cases of

acic lateral curve and straightening of the dorsal spine

most cases of double curve, that in the lumbar region is primary and to the left. In other cases, the antero-posterior curves in the thoracic and lumbar regions are increased; in these the increase of the antero posterior convexity and the lateral curve in the dorsal region are primary, the lumbar spine being laterally



Lateral curvature—long single curve. (*Ernst*)

PLATE 144.

curved, but with increased antero-posterior curve in compensation for the dorsal deformity.

If the assumption of the bad posture be not soon counteracted, by recourse to periods of activity alternating with those of rest, and especially by active movements in directions opposite to the deformity, adaptive changes occur, at first more obvious in the soft tissues, and later evident also in the skeletal structures, the curvature of the first stage passes into the rigid or fixed type. Spinal movements become restricted both on account of the shape of the spine and of the shortening of the tissues on the concave side. The tissues on the convexity are lengthened, and both muscle groups become wasted and weakened. The changes in the vertebræ are most marked near the maximum part of the curve. The [illegible] upper and [illegible] ttress- [illegible] with- [illegible] discs [illegible] exity. Similar changes are seen in the compensatory curve, and where these curves join, the "transitional vertebræ" become more rectangular in shape, although oblique in position. The articular processes, and the neural arches and their processes, are deformed, and the canal becomes ovoid The joints are altered in shape, and restricted in motion from involvement of the ligaments. In advanced cases the degree of fixation may be extreme, owing to osteophytic formation and ossification of the ligaments, with production of ankylosis at the prominent part of the curve. The secondary deformities are most striking in the thorax, which may assume a rhomboid form; the ribs on the side of the convexity project backwards for some distance (sharing in the rotation), and then turn sharply forwards. The chest on this side is flattened laterally and in front, and its capacity diminished. On the concave side the chest is hollow behind and prominent in front, and its capacity is increased. The ribs are elevated on the convex side, and crowded together on the concave. The antero-posterior diameter of the chest is increased or diminished. If the curve involves the lower cervical spine, a torticollis may be simulated. The sacrum and pelvis may be involved in the rotation deformity of a lumbar curve, or the pelvis may be raised on the side of the concavity The pelvis is only badly deformed in severe rickety cases In serious deformity of the chest, the heart and lungs may be compressed, displaced, and hampered.

Etiology.—The occurrence of scoliosis in school children is variously estimated from 1·5 to 25 per cent It is four or five times more common in females than in males The age of onset is difficult to determine, as many cases come for treatment only when the deformity is marked and fixed, of these about 40 per cent. are less than 14 years of age, 50 per cent. between 14 and 21, and 10 per cent. over 21. In all cases of scoliosis gravity is an important factor in increasing the initial curve and in the development of the deformity. Other predisposing causes—active growth, debility, fatigue, overwork, ill health—are sometimes also easily recognizable. In a small proportion the exciting cause is apparent, but in the great majority, in which no disease is present and in which we are dealing merely with a deformity, it is difficult to explain why the spine should bend, and why to one or the other side. The centre of gravity of the sitting body is high, and well above its base or point of suspension (the buttocks), which is relatively narrow; thus the trunk is mechanically in a condition of unstable equilibrium. Balance, which would be far less easily maintained were the spine a rigid structure, is preserved in virtue of the flexibility of the column, which bends normally in

gravity effect due to habitually carrying weight on one ... is ... Co... ve...
lumbar or upper dorsal regions, and may be single or multiple. The curve is usually short and sharply angulated laterally. Often it is associated with fused or absent ribs, cervical ribs, or with congenital elevation of the scapula (*Sprengel's shoulder*). (5) *Compensatory*, to tilting of the pelvis due to adduction deformity of the hip, which acts whether the patient be standing, sitting, or lying, and may produce a very severe fixed deformity with much rotation in the opposite direction in the lumbar or dorso-lumbar region; or to short leg, or to apparent lengthening of the leg in equinus deformity, both of which act only during standing, and produce a very slight curve that does not increase. (6) *Torticollis*, especially neglected congenital cases; the curve is concave towards the affected side of the neck, and extends well into the thoracic spine. (7) *Chest diseases*—empyema and fibroid lung. (8) *Spinal injury or disease*—spinal caries, fracture, rheumatic and traumatic spondylitis. (9) *Other occasional causes* are sciatica, lumbar neuritis, infective myositis of the psoas or of the lumbar muscles, sacro-iliac disease, perirenal suppuration, scars and burns, and hysteria.

Signs and symptoms.—The deformity and posture are most frequently the first evidence of the existence of scoliosis. One shoulder is high or projects backwards, the front of the chest is prominent on one side, one hip is prominent ("growing out"), or the child sits badly. The patient is first examined standing, with the shoes off. The level of the pelvis and the length of the legs are tested by placing the thumbs on the anterior superior spines. In three-quarters of the cases the left leg is from ¼ to ½ in. shorter than the right, but occasionally the reverse ... met ... teri... wai... the ... ther ... of the neck. The ribs and the scapula project backwards, the latter being rotated and pushed away from the spine, and the arm hangs close. Viewed laterally, the spine ... it, with ... from ... with a ... a double ... rather prominent just where the two curves join. Severe rotation, denoting fixed or structural changes, may be obvious in backward projection of the chest wall or of the lumbar region, but lesser degrees may be masked in the erect position, and are then usually tested by noting the contour of the back, viewed from one end, when the patient is made to stand with knees extended and asked to touch the toes. The degree of fixation of the lateral deviation is tested by suspending the patient by the head, or by observing the amount of diminution of the deformity when she is lying prone. Further evidence of fixation is gleaned by active movements of the spine in all directions; restriction of movement first occurs in the ... which correct ... ... when sitting, to change the habitual posture. The general condition of the man nutrition is observed, the signs of rickets elsewhere, the presence or absence of debility, paralysis or of

adaptation. It is easy to imagine that the slightest asymmetrical factor, such as some want of development, trick of position, unequal use of limbs, eyes, etc., would suffice to upset the poise of the trunk and spine, and be the direct cause of the initial curve, which gravity afterwards develops and fixes.

This bigger group, of obscure etiology, consists of those cases usually known as *static*, *postural*, or *adolescent*, the majority of which are met with in older

a neurotic tendency, or a peculiar or irritable temperament in the patient, or a neuropathic family history. It has been held generally that the direct cause of these cases in school children has been fatigue and improper posture, especially in sitting, the latter being fostered by bad seats and desks. Improper attitudes may also be assumed, and thereafter become habitual, in sleeping and in standing; but these positions are of far less importance than sitting, in which the muscles are relaxed, the lumbar lordosis lost, and a *lateral curve likely to be produced. Bankart maintains that postural scoli*osis is not due to faulty attitudes at school, nor purely to debility and muscular weakness; he points out that it is essentially a progressive deformity, and its rapid progress and fixation are out of all proportion to the mechanical factors; it is not a deformity occurring in weedy girls, most of the patients being

e or
th a
that

the mental condition is far oftener of greater significance than the physical aspect of the deformity, he says that abnormal postures are primarily nervous or mental in origin, that postural scoliosis originates as a functional nervous disorder, and that gravity is a secondary, though important, cause. Gravity plays a part in the development, but the early fixation of the deformity is due to the contracture of the soft parts of the concave side of the curve. The muscles on the concave side remain shortened, and, like the non-paralysed antagonists of paralysed muscles, their power of elongation is soon permanently lost. In paralytic cases the faulty innervation is due to an organic

posed. Gravity may cause deformity of the softened bones, but there is a *loss of muscle-tone also* *The common spinal deformity is kyphosis*, which is produced before the child begins to walk, and with or apart from which lateral

with a short spine,
coliosis The com-
produce scoliosis in
bdominal muscles;
of general weakness coming on when the
scle,
side
pen-
ixed

deformity can occur in paralytic scoliosis, but the structural changes may be slight and long delayed. Scoliosis is also met with in some nervous diseases, e.g. syringomyelia and Friedreich's ataxia. (3) *Occupation.* This is a pure

s associated with
ion of the scapula

or lying, and may produce a very
in the opposite direction in the lumbar or dorso-lumbar region; or to short leg, or to apparent lengthening of the leg in equinus deformity, both of which
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with the shoes off. The level of the pelvis and the length

backwards, the latter being rotated and pushed away from the spine, and the arm hangs close. Viewed laterally, the spine may be flat throughout, with diminution of its antero-posterior curves, and with the chest flattened from front to back; or the dorsal spine may be very rounded or kyphotic, with a short trunk and thick chest, and with the lumbar spine lordosed. In a double curve, the spine may be rather prominent just where the two curves join.

the contour of the back, viewed from one end, when the patient is made to stand with knees extended and asked to touch the toes. The degree of fixation of the lateral deviation is tested by suspending the patient by the head, or by observing the amount of diminution of the deformity when she is lying prone. Further evidence of fixation is gleaned by active movements of the spine in all directions; restriction of movement first occurs in those directions which correct the deformity. From the front view will be estimated the asymmetry of the chest, the range of expansion on respiration, the prominence of the abdomen and the condition of its muscles, and the presence or absence of torticollis. The patient is also viewed when sitting, to observe the habitual posture. The general condition of the musculature is observed, the signs of rickets elsewhere, the presence or absence of definite paralysis or of

respiratory obstruction, and inquiries are made as to the rate of growth of the child, her general health, disposition and temperament, her habits and methods of work, and the family history. In adolescents and adults, pain or fatigue may be felt at the site of maximum convexity, especially in the lumbar region. In cases of extreme deformity, pain may occasionally be very severe, and referred along the dorsal or lumbar nerves, on the convex side. Neurasthenic or hysterical symptoms are not infrequent. Children with curvature are inclined to be sedentary, and awkward and inco-ordinated in movements during adolescence Severe deformity causes liability to respiratory and circulatory troubles in later life.

Prognosis. [illegible] ntion compared with the results of t [illegible] scoliosis. The deformity is ofte [illegible] in the first or simple postural stage. In most adolescents and adults all that can be done is to restore the symmetry of the trunk as far as possible, check the progress of the deformity, and relieve symptoms. Correction of the curve is possible only to the extent that the spine can be made flexible, and this will depend on the amount of rotation present The curve and the asymmetry of the body may be considerable, while the fixed changes are slight; in such a case a marked improvement will be obtained. On the other hand, lateral deviation may be little and rotation great, in which case little improvemen [illegible] but if it is fixed, [illegible] trunk by further [illegible] In the history of [illegible] assumption of ba [illegible] by the restriction of movements and the skeletal changes In most adolescent cases the deformity progresses for a time, becomes most frequently compen- [illegible] and arrested when [illegible]

cannot be avoided.

Prophylaxis. [illegible] not be maintained [illegible] muscular [illegible] ed, and the necessary rest should be taken lying down. Physical, and more especially mental, overwork and fatigue must be avoided; fatigue increases curves, whether normal or pathological. "The child who sits badly is one who is overtaxed mentally" (Bankart).

Constitutional treatment.—The general health must be maintained, and debility, anæmia, enlarged tonsils and adenoids, constipation, rickets, etc., suitably treated. Clothes should not hamper movements, and exercise should be taken freely in the open air. If possible, occupation and environment should be changed.

Restoration of movements and correction of deformity.—Restriction of movements must be overcome before the deformity can be corrected or the patient trained to maintain the correction by muscular control. Correction can only occur to the extent that the spine is made flexible. Daily passive movements, done by a gymnast for twenty to thirty minutes, are essential if there is any rigidity. Hanging from a suspension

apparatus, by the arms or the head, and fixation in directions opposed to the deformity in some splint, plaster jacket, or plaster bed, are varieties of passive stretching. Strong active exercises have also a passive mobilizing effect. Passive correction of rotation—the most difficult correction—is most assisted by rotation of the affected part of the trunk when the spine is moderately hyperextended. Deformity elsewhere, such as torticollis or adducted hip, to which the spinal curvature is secondary, must be corrected; and inequality of the legs compensated by a raised shoe.

Forcible correction.—This method is indicated in children and adolescents for slighter degrees of deformity which resist remedial gymnastic treatment, and when body asymmetry is disproportionate to the fixed changes in the spine. The success of the method depends on the flexibility of the spine. The Scoliosis Committee of the American Orthopædic Association in 1916 found that no case of fixed scoliosis had been shown to be corrected, in the anatomical sense, by any method. The method most usually adopted is that of the plaster jacket, applied when the patient is suspended and with the deformity corrected as far as possible by lateral traction. Windows can be cut over the concavities, and extra padding with felt applied to the convexities and rotation prominences. The jacket may be made removable for the purpose of applying extra padding, and to permit daily passive correction and active exercises; in hospital practice, it may be left fixed. The jacket is renewed after an interval of a couple of months; and at the termination of this treatment an appliance is supplied, or care is taken to re-educate the patient to maintain the correction. Plaster jackets are especially useful for the correction of deformity in paralytic and rachitic cases. In 1911 Abbott advocated a method of forcible correction with the spine well flexed, maintaining that

period.

Muscular re-education.—Exercises are important. Postural scoliosis is due not to muscular weakness, but to deficiency of the habitual subconscious state of reflex activity which normally maintains the upright attitude. The object

particular muscles as

reflex habit. The vol

repeated until it becomes involuntary, subconscious, and habitual The

and co-ordination. Dancing and games are also very useful in this connexion. In single curves of the first stage, where movement is not restricted by rotatary changes, symmetrical or bilateral exercises are indicated. Special attention should be given to the development of the respiratory movements, the abdominal muscles, and the spinal extensors. Corrective exercises are difficult to apply in a case of double curvature, as those which correct one curve make the other worse. Exercises prevent the occurrence of curvature, and will effect a cure in the early stages only; but they are important for maintaining strength and relieving symptoms at any stage. A flexible curve that can be corrected actively or passively will be kept straight when the postural reflex

is re-established. A fixed curve will be corrected by exercises only in so far as it can be made flexible. The flexibility may be increased, but it rarely becomes complete. An ordinary adolescent case usually, for about six to twelve months, requires exercises under supervision, which are afterwards carried out at home as a regular daily practice. If the curve is not thereby checked, it should be mechanically supported, at least until the period of growth is over, the home exercises being continued meanwhile.

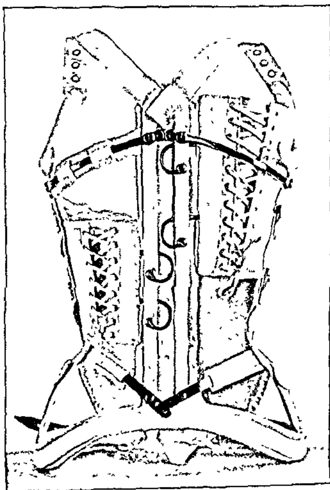


Fig. 904.—Spinal appliance for lateral curvature. (*Ernst.*)

Mechanical support.—Spinal corsets (Fig. 904) or appliances are always required in severe cases, to prevent pain and increase of the deformity. They are retentive, and rarely corrective. Some cases, such as those due to [illegible] paralysis, or cases of severe deformity in old [illegible] pported from [illegible] t also, to pre- [illegible] the pressure [illegible] ser abdomen

is well supported, the lumbar lordosis preserved, pressure is exerted . . .
rotation prominences, and the chest and the upper . . .
free. In slighter cases an appl . . .
suffice, or even merely a low . . .
sary only during the grow . . .
being omitted with safety whe . . .
Support may be necessary in . . .
to co-operate in the exercise . . . plaster bed is fre-
quently employed, in which . . . sleeps with the spine in the position
of greatest correction

KYPHOSIS AND LORDOSIS

The antero-posterior curves of the spine vary considerably within normal limits. The spine at birth forms a single convexity backwards throughout its length; the cervical curve is first developed when the child holds up its head; and the lumbar later, when standing is assumed. Whitman points out that, normally, some patients stand symmetrically poised with an exaggerated dorsal curve compensated by a similarly excessive lumbar lordosis. In others there is a general backward curve throughout the lumbo dorso-cervical spine, with a compensatory kink immediately above the sacrum, and the head, shoulders and scapulæ are "poked" forwards. The chest is usually flat and the abdomen prominent—a fatigue attitude, and one which predisposes to scoliosis. It may be associated with other postural deformities, such as flat-foot. In others again the spine is very flat throughout.

Kyphosis ("round shoulders") results from many causes. It may be a purely static or postural weakness, similar in origin to scoliosis, and is met with in infancy, in adolescence, and in old age. The deformity is mainly confined to the dorsal region. It is fostered by the presence of large tonsils and adenoids, or other causes of deficient respiration, or by the restrictive effect of the weight of the clothes on the shoulders. The chest is narrow, deep and flat. In infants it may be associated with spastic, mental, and other conditions where sitting and walking are delayed. Laborious occupations, entailing heavy lifting and carrying, may be another cause, especially if incurred before growth is complete, in which case the deformity may be very severe. Rickets may cause a kyphosis in the lower dorsal region in children, which may further lead to scoliosis. Rheumatoid spondylitis may cause a kyphosis throughout the entire spine; and to preserve balance, in the absence of the lumbar lordosis, the patient may need to stand with the knees and hips flexed. In late life a senile osteo-arthritis causes a similar deformity in the dorsal region. Osteitis deformans also produces a long kyphotic curve. Tuberculosis of the dorsal spine may produce angulation, most frequently of the typical pointed variety; but occasionally, when the infection extends along the anterior common ligament, and involves several bodies, the deformity is more rounded, and difficult at times to distinguish clinically from that due to occupation. A dorsal kyphosis of a severe type may occasionally and rapidly supervene after injury of the spine—traumatic spondylitis. The X-ray examination of some adolescent cases has revealed a broken-up appearance of some of the epiphysial plates of the vertebral bodies, similar to that seen in the head of the femur in osteo-chondritis of the hip-joint (Perthes' disease), and it has been thought, consequently, that this process accounts for some of these deformities. Dorsal kyphosis can also be compensatory to increased lumbar lordosis.

The deformity causes weakness and fatigue. Chest expansion is deficient

owing to accommodative changes. In infective cases complete, and in others partial, ankylosis may result.

The **treatment** is along the same general lines as in scoliosis Active and passive exercises serve to increase the mobility and correct the deformity. The respiratory capacity is developed and all obstruction to breathing removed A spinal appliance may be worn to hold the shoulders back while leaving the chest free; this may be made to exert a corrective effect. In postural cases with rigidity, and in those in which active inflammation has subsided, the deformity may be corrected by forcible rectification under an anæsthetic, followed by fixation in correction in a plaster jacket—the process being repeated if desired. In the acute stage of inflammatory conditions the patient should be recumbent, or allowed to walk about in a protective jacket, as the case may need; in either case the spine is held fully extended.

Lordosis.—Increase of the forward curve of the lumbar spine ("hollow ... of the dorsal

maintain the balance, in the absence of sufficient support from the muscles Its treatment will depend on that of the primary condition. A too hollow back is usually tiring and painful, and relief may be provided by a low corset or belt which well supports the lower abdomen.

CONGENITAL ELEVATION OF THE SCAPULA

Sprengel's deformity is a congenital condition in which the scapula is raised and fixed in the upper part of the shoulder, above the clavicle. It is also rotated, the inferior angle being nearer the spine; and it may be smaller than its fellow. The deformity is probably due to some compression of the fœtus in utero. The condition may sometimes be bilateral, and occasionally it is an hereditary mainfestation. It is more often than not associated with some other congenital malformation—scoliosis, torticollis, wedge-shaped vertebræ, or anomalies of the ribs. The muscles passing from the spine to the vertebral border of the scapula are shortened, and in some cases the upper angle is ... movements of the arm,

exercises.

DISABILITIES OF THE LOWER SPINE. ("PAINFUL BACK")

Various abnormal conditions of the skeleton, resulting from arthritis, trauma, improper postures, etc., occur in the lumbo-sacro-iliac regions and cause such symptoms as backache, weakness, stiffness, local pain and tenderness, and referred pains in the legs, the origin of which may be obscure and the diagnosis difficult. Formerly, after eliminating gynæcological and visceral conditions, and excluding gross affections such as tuberculous disease of the spine or sacro-iliac joints and lateral curvature, pain in the ... lumbago, muscular sprains, ... an orthopædic surgeons ... , and show that the dis- ... etal cause.

Chief physical signs.—In examining a case of "painful back" it is necessary to note any restriction of movement of the lumbar spine in one or more directions; unilateral or bilateral muscular spasm; abnormal level and tilt of the pelvis; differences in relative length of the legs; abnormalities in the lumbo-sacral angle (the promontory); lumbar lordosis or flattening; the existence, with or without rotation of vertebræ, of general or localized lateral curvature of the spine; the range of movement of the hip-joints; depression of the sacrum relative to the posterior superior spines on one or other side; sensitive or tender spots—whether over the sacro-iliac, lumbo-sacral, or interlumbar joints, over the spinous processes or interspinous ligament, or in the lateral muscles; the general posture and existence of a prominent abdomen and flat chest; and the distribution of motor and sensory signs in the legs, including tenderness of the sciatic nerve.

Symptoms.—Common symptoms are pain and aching in the lower lumbar region, central, or on one or both sides, perhaps referred to the buttocks or down the front or back of the legs, or even to the foot. The back is weak and stiff, causing fatigue and disinclination for exertion or exercise. At times, associated with a kind of locking, there are sudden sharp attacks of pain, which may pass off, but are liable to recur; "something seems to have given way or broken at the bottom of the back." The pain may occur in standing only, and be absent on sitting or lying, or vice versa. If the symptoms have persisted for some years the patient may become neurasthenic. The diagnosis of many of these lower back affections is quite impossible without good stereoscopic radiograms.

Causes.—(1) **Relative shortness of one leg,** usually the left, is present in many people and causes a simple postural curve, convex to the side of the short leg, and involving the lumbar spine alone or the sacrum as well. If rotation of the vertebræ be present, unilateral aching of the lumbar muscles may occur when the patient is fatigued. The short leg throws more strain on the sacro-iliac joint on the same side; derangements of the joint are more common on the left side.

(2) **Lumbar lordosis** of exaggerated type may cause backache. The concavity may be confined to the lumbar spine, or the sacrum may be excessively tilted, with increased lumbo-sacral angle and a depression above the sacrum simulating spondylolisthesis. In children, excessive lumbar lordosis, prominent abdomen, round shoulders and flat chest constitute a fatigue posture. In adults, lumbar lordosis may be associated with prominence [illegible] cles.

(3) [illegible] nother may cause [illegible] by a hyper-extension injury, or may, in athletes and workmen, result from the large size of the processes.

(4) **Tearing of an interspinous ligament** by sudden forced [illegible]

[illegible] hing of the back [illegible]

(6) **Infective arthritis of the spine.**—Infective arthritis of the lumbar spine occurs as two common types The ossifying variety, *rheumatoid spine* (spondylo-rhizomélique of Marie), usually begins in the lumbar region and spreads progressively up the spine until the dorsal and cervical regions are involved It is a disease of young adults. It is ushered in with vague abdominal pains, and for years may be mistaken for lumbago. The lumbar spine undergoes progressive ankylosis in the flexed position

(obliteration of the lumbar curve)—the resting or sitting position. No condition makes the spine more generally and permanently stiff All the ligaments connecting the vertebral bodies become ossified, and the spine is converted into a solid mass. Although the process may terminate at any stage of the ankylosis, it usually gets worse, *until no more joints are left* to ankylose, unless an etiological infective focus be found and eradicated. *In some cases both hip-joints become involved a year or two after the spine* is affected, but no other joints in the body are ever attacked in this type, *except occasionally the* sacro-iliac joints. The spine may, however, be involved together with all other joints at a late stage in generalized rheumatoid polyarthritis—a quite different clinical condition

The lowest lumbar vertebræ may develop a more local affection, of the nature of *hypertrophic osteo-arthritis*, such as is seen elsewhere, e.g. in the knees. This type also is probably infective, perhaps initiated by injury, but must not be confused with the purely traumatic conditions seen in the articular processes, *in the lumbo-sacral junction (spondylolisthesis)*, or with traumatic spondylitis It is a disease of late adult life. Lumbar rigidity occurs, with local pain, but the stiffness is not nearly so marked as in rheumatoid spondylitis, and the lumbar spine is not so flattened. *Osteophytes form on the edges of the vertebral body, and the discs are thinned*, but ossification does not bridge across the separate vertebræ as in rheumatoid spondylitis. On rare occasions this type of arthritis is associated not merely with sciatic pains in the legs, but with actual motor paralytic lesions, usually unilateral, in which it is difficult to say whether the neuritis or the arthritis is primary, or whether both are due to some common toxic cause.

(7) Sacro-iliac joint.—The *sacro-iliac joint* is liable to various infective and traumatic conditions. The joint is an L-shaped articulation from the apex of which two limbs, a horizontal and a descending, diverge. The articular surfaces of these limbs are covered with fibro-cartilage, and to their margins is attached a continuous layer of synovial membrane

Thus the true joint cavity [illegible] small area

limited to the most interior

and descending limbs U[illegible]

is diarthrodial, with the maximum movement in an antero-posterior plane [illegible] part of the joint At puberty the male joint becomes [illegible]amework is harder and more com[illegible]rior sacro-iliac ligaments thicken; and finally an osseous tubercle develops on the articular surface of the sacrum at the junction of the two limbs, which fits into a corresponding depression on the ilium, thus tending to lock the joint and to render the articulation *firmer. In the female the joint remains freely movable* until the menopause. During pregnancy there is a softening of the articular tissue to facilitate the passage of the fœtus during labour. The capsule becomes lax, and freedom of movement of the sacrum in the vertical plane is increased. After labour, if uterine involution is normal, *the ligaments contract up and return* to [illegible]

eve [illegible]

the [illegible]

are liable to a non-tuberculous infective arthritis involving [illegible] frequently both, similar to the infective arthritis (villous synovitis) *found* elsewhere, e.g. in the knees. No other joints need be involved. It is liable to follow influenza and other general infections, and must be *distin-*

guished from the typical rheumatoid affections mentioned above. Pain in the joint is sharp in every position assumed, and is little relieved by mechanical treatment with a belt; local tenderness is acute, and the joint may be slightly swollen and puffy. Skiagraphically, the condition is distinguished from tuberculosis by the very localized fluffiness of the joint surfaces, while the neighbouring bone is hard and not atrophic; there is no tendency to abscess or sequestrum-formation or to pathological dislocation as in tuberculosis. The interior of the joint may show swollen and congested synovial membrane in parts, and attempts at osseous ankylosis in others.

(ii.) *Sacro-iliac relaxation, subluxation, or strain.*—Undue mobility, strains, acute subluxation, and recurring subluxation may occur as traumatic affections, producing disabling symptoms somewhat resembling those of sacro-iliac disease. There may be definite history of trauma, such as a fall on the buttocks, a strain at golf or tennis, or in cranking up a car; or the history may be vague, in which case other factors, such as a chronic strain due to excessive walking, standing, or exercise in patients with long lean or with stout flabby backs and poor muscles, may predispose. The condition may be produced by pregnancy, owing to the relaxation of the pelvic joints, or predisposed to by long confinement to bed on account of illness. Occasionally the sacro-iliac joints are unduly mobile on one or both sides, as evidenced by the grating on spinal and pelvic movement, but are painless. A typical case of sacro-iliac "slip" or "strain" may result from a fall on sacrum or buttocks, or from excessive muscular exertion when the spine is flexed. Something may be felt by the patient to give way, usually on the left side. Sharp pain is experienced in the joint, which then becomes tender on pressure; and the pain may radiate along the sciatic nerve. Pain referred to the joint may usually be produced either by for[illegible]
of the hip j[illegible]
abdomen. [illegible]
pletely or [illegible]
creasing frequency. Two types of displacement have been described. In the first, the forward inclination of the sacrum, relative to the ilium (normally about 25°), is increased on one side (or on both) The upper end of the sacrum is displaced forward and slightly downward from the ilium. It is not dis-[illegible]

[illegible]

times be detected in a stereoscopic radiogram; it is rarely more than about $\frac{1}{4}$ in., and may be less. In the second type the lumbar lordosis is lessened and the sacrum becomes more perpendicular, in which case its upper part is displaced backward relative to the ilium. If an acute subluxation remains unreduced, the pain and discomfort continue more or less continuously, with exacerbations from time to time. The condition is amenable to complete reduction and relief by manipulation under an anæsthetic, in the direction of flexion, extension, and antero-posterior rotation of the ilium on the spine; this should be followed by a fortnight's rest in bed, the pelvis being firmly strapped. Where the condition is of long duration, and liable to frequently recurring attacks of spontaneous subluxation and reduction, it cannot be cured by manipulation under anæsthetic. If a belt or sacro-iliac girdle fail in these cases—which, however, is unusual—the joint must be ankylosed by some arthrodesing or bone-grafting method. The chronic type consists in an unduly mobile and painful joint which is weak and insecure. In some cases bilateral pain exists, the sacrum being subluxated forwards and downwards on both sides.

(10) Localized traumatic arthritis of one of the joints formed by the articular processes between the fifth lumbar vertebra and the sacrum, or between the lumbar vertebræ, may cause continuous or intermittent local

of an articular process. Treatment is by means of a spinal appliance, designed to prevent mobility and relieve the injured joint from strain. If this fail, an operation for spinal bone-grafting or "spinal fusion" is indicated. Injury of the articular processes of one or both lumbo-sacral joints may lead to a partial spondylolisthesis.

(11) Undue development of one transverse process of the fifth lumbar vertebra has been held to be a cause of pain in the back from pressure on the ilium, and the excision of the process has been recommended. At times one or other process is very large, and attached to the ala of the sacrum—sacralization of the fifth lumbar vertebra. The condition is often detected in the routine X-ray examination of painful back, but also when patients are examined for other conditions. It is a congenital anomaly and its only pathological significance is that, in so far as it must limit the normal movements, it renders the spine more vulnerable. The effects of injury are most marked where a movable part of the spine joins a fixed one, e g. near the twelfth dorsal and the fifth lumbar vertebra (Openshaw).

Of the primary muscle conditions causing pain and stiffness in the lower back the commonest is (12) fibrositis or lumbago. This usually results from exposure, and may be of infective origin. At other times it is more closely associated with strain or injury, or falls into the class of "fatigue rheumatism" Its characteristics are sudden onset, great pain on movement, and considerable rigidity, at times its disappearance is as sudden as its onset, the patient being left perfectly free. On occasions, from a unilateral involvement of the muscles, and in association with sciatica, lateral curve results—(13) sciatic scoliosis, which may be a temporary or a permanent deformity. (14) Actual strains of the fibrous tissues and muscles may be difficult to distinguish from toxic fibrositis, but the history of the injury and the very local tenderness will differentiate them. Spasm and fixation are more marked in fibrositis.

(15) Infectiv
times met with,
in another part
the psoas muscle
temporary lumb
muscles Pain, tenderness and temperature may exist for several months The inflammation may resolve, or an abscess may form

Sciatica, although sometimes toxic, or a referred pain from spinal disease, is often merely a symptom of one or other of the mechanical conditions enumerated above. Before deciding upon the regime of rest, etc., which the treatment of toxic neuritis demands, an effort must be made to determine whether the sciatica is mechanical in origin, a referred pain due to some displacements in the lower spinal and pelvic joints Mechanical displacements may require manipulation under anæsthetic for their correction. When this has been done in those cases not obviously infective in origin, the resting treatment can be instituted later if necessary.

(16) Backache from abdominal and pelvic visceral affections, or associated with (17) neurasthenia, is that from which most of the conditions enumerated above have to be diagnosed.

KNOCK-KNEE AND BOW-LEG

These common deformities of the legs occur or progress mainly at one of the two periods of activity and development—when standing and walking are assumed in infancy, and during adolescence. *The important predisposing* cause is strain due to the rest posture and to body-weight. In adolescence the effect of laborious occupations and fatigue is added. Rickets is the only important exciting cause in some cases, but in many there is no sign of disease whatever If the condition is very severe, it is usually accompanied by generalized deformities; otherwise rickets may involve only the legs. Posture is therefore an important factor in the production of most of these deformities A few, however, occur from other causes, e.g. osteo-myelitis, osteo-arthritis, malunited fractures, or are secondary to deformity at the *hip-joint or in the foot. Deformities of the lower extremities are more common* even than scoliosis. Bow-leg occurs more frequently than knock-knee, and both are said to be more common in males than in females. Bow-leg develops earlier than knock-knee, perhaps even before the child begins to walk. The tibiæ may be congenitally bowed; this may become exaggerated by the separation of the legs necessitated by the use of bulky diapers, and later by the child's attitude in sitting tailor-wise. When the child walks the deformity may increase, but frequently it spontaneously improves. Bow-leg met with in adolescent or adult life, if not the result of injury or disease, has usually existed from early childhood *On the other hand*, knock-knee does not often occur before the child begins to walk, and is first noticed after he has been walking for a year or so; it is far more prone than bow-leg to occur in adolescence, and most of the cases either develop

ness of the leg
when not due
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the hips and knees in standing, and prevent the feet from becoming everted,

of weight-bearing. *The lines of trabeculæ are determined by the* positions of bones in relation to gravity, in the upright position. These habitual positions are determined by the postural activity of the muscles, and so deficiency of the normal postural activity causes the lamellæ to come out of alinement with the force of gravity. Thus Bankart thinks that inability to withstand weight in bone is equally a result of *deficient* postural activity as in similar defaults in muscles. Owing to poor general health, mental and physical fatigue, overwork, improper feeding, neurosis, etc, the postural activity becomes deficient, and improper attitudes are assumed. *The patient yields to, instead of counteracting*, the effect

of gravity on the natural structural weakness of the knees. Bow-leg may be normal in, or more characteristic of, the vigorous child, while the weak infant becomes flat-footed and knock-kneed.

The liability to spontaneous cure of these deformities in children with increasing age and growth is well recognized. The capacity for improvement will depend on the degree of deformity and on the rapidity of improvement in general health. Mild cases with few or no rickety symptoms will improve as the muscular tone and postural reflexes develop and the attitudes improve, and, in the more severe cases, as the active disease subsides. Severe rickety deformities do not tend to be outgrown in those cases where general growth is checked, nor will any deformity improve if general health and hygiene remain deficient. A deformity existing after the age of 5 or 6 years is unlikely to disappear spontaneously. Many adults retain a mild degree of deformity that originated in infancy.

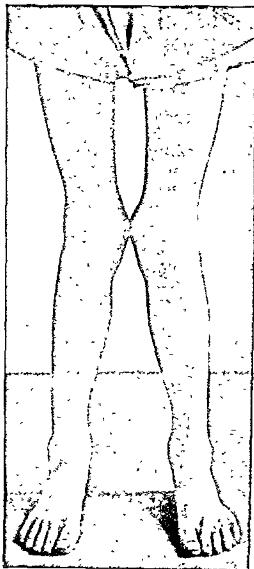


Fig. 905.—Adolescent genu valgum. (*Ernst.*)

Genu Valgum (Knock-Knee)

Pathology.—The angle which the femur normally makes with the tibia varies with the width of the pelvis and the length of the leg. The knee-joint is horizontal. In genu valgum the tibiæ are out of the perpendicular and, when the patient stands with the knees extended and touching, a gap exists between the malleoli. (Fig. 905.) At first the deformity involves the liga-

and can be corrected by voluntary effort. But in the later stage structural alterations occur in the articular ends of the tibia and femur, and in the adjacent portions of the shafts. In this stage although the def- [illegible]

transmitted principally through the outer part of the joint, and the ligaments and tendons of the inner side become overstretched and those on the outer side contracted. The epiphysial lines are oblique, and the inner parts of the epiphysis slightly deepened; but the principal deformity is due to bending of the adjacent portions of the shafts, and very little to the alteration in shape of the condyles and tuberosities. The inner tuberosity of the tibia is raised, and the inner condyle of the femur lowered, by this alteration of the shape of the shaft. When the deformity is due to rickets, the characteristic epiphysial changes may be observed. In persistent deformity in adults, synovial and arthritic changes appear as a late result. The internal structure of the epiphysis and the shaft is more dense and less spongy on the outer side, where it has to sustain the greatest weight. Sometimes the knees are hyperextended (genu recurvatum), this probably being favoured by a contracture of the tendo Achillis, which is often present. When the patient is standing with the knees fully extended, the femur is adducted and rotated in, while the tibia is abducted and rotated out; in this position the deformity is at its worst, as the ligaments on the outer side of the joint are then tight and external rotation is maximal. When the joint is flexed, however, as in sitting, the deformity disappears; the outer ligaments slacken and the tibiæ rotate in, and the effects of the altered condyle and shaft are not apparent in flexion. Flexion therefore eases the strain, and thus severe cases stand with the knees bent. Flat-foot often exists as an associated deformity, especially in children; both are the results of a common cause —deficient postural activity. A child who is improving produces a compensatory inversion of the foot, or in-toeing, and will do so also in severe degrees of deformity. In adults there is usually a compensatory varus. Knock-knee is usually bilateral, but may be confined to or more marked in one limb. Occasionally one leg is affected with knock-knee while the other is bowed; again, a knock-knee may be combined with a bowed tibia in the same limb. In cases due to severe rickets the genu valgum may be associated with other distortions of the limb, such as coxa vara and antero-external bowing of the femur or tibia.

Apart from the ordinary cases of knock-knee occurring in adolescence, two important but less common types are occasionally met with. *Renal dwarfism* is a condition in which severe knock-knee occurs comparatively suddenly at about puberty, or very occasionally earlier, and is associated with interstitial nephritis and stunted general development. These cases terminate fatally at about the age of 14 or 16 from uræmia. Barber says the nephritis is easily overlooked, as the cardio-vascular changes are singularly slight; it is of insidious onset. Albuminuria, although present constantly in most cases, is occasionally absent, and has not been detected at all in one or two recorded cases proved *post mortem*. Other observers have noticed in these cases the frequent occurrence of spontaneous fractures of the diaphysial ends of any of the long bones in the neighbourhood of the epiphysis. Operative correction is contra-indicated, as likely to precipitate a fatal termination, and the treatment should be by appliances. *Late rickets* has been called upon to explain the development of genu valgum at puberty in association with stunted development, but in which there is no visceral

disease. The bony changes, says Barber, are not so marked, as shown by X-rays, as in the renal dwarf, and there is very little evidence that there has been a recrudescence of a former infantile rachitic condition.

Symptoms.—The gait is awkward and shuffling. The thighs are abducted and rotated out to allow the knees to pass each other, and the body
[illegible] and non-
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be felt
ankles;
occasionally synovial effusion may occur. A unilateral knock-knee acts like a short leg, tilts the pelvis, and produces a lumbar curvature. The deformity may be masked by the patient standing with the knees slightly bent, and one in front of the other.

Treatment.—The treatment of genu valgum may be expectant, mechanical, or operative. Slight degrees of deformity in early childhood, out of which the patient may be expected to grow, will not require any drastic treatment. Active rickets will be treated constitutionally by open air, sunshine, phosphates, cod-liver oil, etc, and the child will be kept off his feet. Later, and also in non-rachitic deformities in children, a certain amount of standing will be beneficial, if care be taken to protect the feet and legs, and to avoid fatigue and improper attitudes and predisposing occupations in adults. The legs should be massaged, and deformity passively corrected for ten or fifteen minutes two or three times every day—by pressure of one hand on the inner side of the knee and of the other on the outer side of the calf, the knee being fully extended meanwhile. Flat-foot should be treated by inversion and in-toeing exercises and attitudes, assisted by building up the inner borders of the shoes; the latter relieves strain on both ankle and knee. Special exercises should be given to strengthen the muscles. The result of treatment is noticed in a few months; if it is insufficient, splints will be required. The most useful is the Thomas appliance, consisting of an outside steel bar extending from a pad over the great trochanter to the heel of the boot, with another bar behind the knee, to which the knee can be strapped out and back. No joint is provided, and the child walks with the knee fixed in full extension—the only position in which the appliance can exert a corrective effect Alternatively, a broad splint can be applied on the outer side of the limb, from the trochanter to the socket in the boot, but provided with a rack at the level of the knee, by which the corrective effect of the splint can be gradually increased. Bilateral splints are connected (by free joints at the hips) to a pelvic band In the appliance the patient is permitted to walk about at will. It is removed daily for massage, manipulations, and exercises, and may also be worn at night if it is desired to hurry up the treatment. The appliance will correct a separation of the malleoli of 4 or 5 inches in about six months At the end of this period it should be omitted gradually, but the correct attitudes and exercises must be continued for some months afterwards The efficacy of mechanical treatment will depend on the degree of deformity and the age of the child; it is of very little use for older children. In mild deformity in soft limbs the correction may be obtained more rapidly by repeated moulding and fixation in plaster of paris; or, if preferable (especially in hospital practice), the limb can be forcibly straightened by manual osteoclasis of the femur or tibia, or both, under an anæsthetic, followed by fixation in plaster and afterwards by exercises and massage. No correction should be made until the active stage of rickets is over.

After the age of 4 or 5 years, if the deformity is more than 3 in. in children or 4 in. in adolescents, correction by operation is preferable. This is usually done by the Macewen method, *at the lower end of the femur, and full* correction is obtained at this site even though the tibia shares in the deformity. The limb is fixed in overcorrection in a plaster spica for six or seven weeks, and thereafter massage and exercises are carried out. In severe cases in young subjects a retentive walking appliance is used for several months subsequently to the operation, while the ligaments are recovering from their overstretching. Both femora may be divided at one sitting. When *the deformity is very severe, or is much more marked in the tibia,* the latter bone can be corrected instead of the femur, or in addition to it at a later period. Either a linear or a cuneiform osteotomy is done, immediately below the head of the tibia, and the fibula is snapped by manual force. Some prefer osteoclasis to osteotomy, this can be done manually before the age of 4, or by an osteoclast later. Care must be taken to avoid injury to the epiphysis and the external popliteal nerve.

Genu Varum (Bow-Leg)

Pathology.—*In genu varum the knees are apart when the patient* stands with ankles touching each other. There are two types—(1) true genu varum—the exact reverse of genu valgum—where the deformity involves both the tibia and the femur in the neighbourhood of the knee-joint, altho

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and similar, but reverse, changes occur to those seen in genu valgum. The ligaments on the inner side of the joint are contracted, and those on the outer side overstretched. In late cases there may be some compensatory lengthening of the outer side of the femur and tibia, near the joint. The femur is abducted and rotated outwards, and the tibia rotated inwards. The deformity is most marked when *the knees are fully extended; on flexion,* the knees come into contact, and may even simulate knock-knee. In later life, osteo-arthritis is a complication, resulting from the unfair distribution of weight, and from the later development of abnormal mobility of the joint. The tibia and the femur are distorted, and a crest of new bone forms along the concavity of the curvature. Bow-leg in young healthy infants is not necessarily pathological; it may result from compression of the legs in the

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as the result of riding; it may also occur from osteo-arthritis in old age. Bow-leg is not liable to originate in *the adolescent period; it has usually* persisted from infancy.

Symptoms.—In most cases a mild degree of deformity disappears in *the first year or two,* when the child begins to walk; but in others it may increase gradually until after maturity. The gait is rolling, with the knees set widely separated. The toes are turned in, because of the inward rotation and twist of the tibia. In early rickety cases the feet are flat; and in old

pes valgus, which may cause
nts attacks of synovitis and
are not uncommon, and in

Treatment.

strength of the legs and muscles in proportion to the body-weight, and by the existence or absence of active rickets. A child with a tendency to bow-legs should not be allowed to sit tailor-wise, or to walk and stand too early If the feet are not flat, the shoes should be built up on the outer sides, to relieve the strain on the outside of the knees If the deformity is more severe, or is increasing, a supporting splint or steel, to which the knee is strapped, should be applied to the inner side of the limb, from the thigh to the heel; this can be designed to permit or prevent walking, as seems expedient. With the appliance the daily manipulations and massage and exercises must be continued. Treatment by appliance may be required for six months or more.



Fig. 906.—Rickety bow-legs.

Operation is preferable to mechanical treatment in the severer cases, especially in children over the age of four. Manual or mechanical osteoclasis is employed, or osteotomy; manual osteoclasis is easy before the age of four, but after this osteotomy is preferable. (Plate 146, Fig. 2.) The tibia should be partly cut through, by the subcutaneous method, at the site of maximum curvature, after which the fracture is completed by manual force, and the leg fixed in plaster in slight overcorrection Then follows a course of massage and exercises, during which an appliance may be desirable for a few months while the overstretched ligaments are recovering. *In adults osteotomy by the open method is better*, it may be either linear or cuneiform as desired, the fibula being divided through a separate incision. Usually sufficient correction of the whole leg can be obtained by dividing the tibia alone, but in severe cases it is better to obtain a part of the correction in the femur also, this being done at a subsequent operation.

Anterior Bow-Leg

In this deformity there is a prominent antero-external curvature of the tibia in the lower third of the leg; usually the lateral bowing is very slight. The tibia is flattened from side to side and bent sharply forwards, the crest projecting beneath the skin; the fibula is similarly affected. The con-
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o [illegible]
b. [illegible]
and the dorsum of the foot may easily touch the prominent shin. The stature is lessened, and the patient appears to drop forwards with each step The deformity does not occur until after walking has been begun.

Treatment.—In cases requiring correction, osteotomy is usually necessary. Correction is easier after cuneiform than after linear osteotomy, but the former tends to diminish the length of the tibia; in correction by either method tenotomy of the tendo Achillis may also be required. Correction of this deformity in the lower part of the tibia is liable to result in non-union after osteotomy; hence some surgeons prefer osteoclasis, which, in cases of extreme bowing, may be repeated at different levels, at intervals of three or four months; others advocate multiple osteotomies (up to six or more) at one sitting. The author prefers to complete the correction at one operation by a cuneiform resection, the fragments being fixed by a metal plate, or by a graft from the upper fragment slid across the gap, as a precaution against non-union.

Genu Recurvatum

Genu recurvatum, the deformity resulting from excessive hyperextension of the knee-joint, may be of congenital or of acquired origin. Congenital genu recurvatum is the result of malposition in utero, the knees having been extended, with the feet beneath the chin, the patella may be incompletely developed or absent. Acquired cases result from various causes—infantile paralysis involving the gastrocnemius or the hamstring muscles, or both; malunion, with angulation backwards, of the mid-shaft of the femur, or of the upper end of the tibia; rupture of the crucial ligaments; prolonged recumbency in bed, as e.g. in hip disease; as a deformity secondary to talipes equinus; and, in slight degrees, in association with genu valgum. The association of talipes valgus, slight contracture of the tendo Achillis (equinus), knock-knee, and genu recurvatum is very frequent, and it is possible that the primary defect in these cases is a slight degree of congenital equinus, and that this is one of the causes of non-rachitic genu valgum in childhood. *The shortened tendo Achillis produces, as secondary deformities,* pes valgus and genu recurvatum; pes valgus further predisposes to the production of knock-knee. In extreme deformity the patient stands and walks with difficulty. In most cases there are weakness and insecurity, and perhaps pain, in the knee; the latter may be very troublesome in cases resulting from malunited fracture, and is due to pinching of the synovial membrane in the front of the joint. The soft tissues behind the joint are overstretched, and those in front contracted. In adult cases the articular ends of the bones, especially the head of the tibia, become altered in shape

Treatment.—Congenital cases, which may be complicated by contracture of the extensor muscles, are corrected gradually by manipulations, combined with the use of a plaster or other splint which holds the joint in a flexed position; later, passive and active movements are employed. After the walking age, especially in cases due to poliomyelitis, the limb is used

with the knee fixed in an appliance preventing complete extension. When the deformity is secondary to talipes equinus, the tendo Achillis must be lengthened. In cases due to malunion, the alinement of the bone must be restored. In advanced cases in adults an appliance can only be palliative, and to obviate its permanent use an operation is required. The tibia is divided transversely about one inch below the knee-joint, and the line of bone section opened up, by angulating the fragments, until a wedge-shaped gap in the bone is produced, of much greater angle than that of the hyper-extension deformity. The limb is then fixed on a back splint, with the knee-joint flexed and the fragments angulated, for three or four weeks,

for three or four weeks more, in order that consolidation may become complete. The patient is allowed to walk in a calliper splint for the next three months, to protect the joint from over-extension strain. By this operation the over-extension of the knee-joint is compensated by an angular malunion of the upper end of the tibia.

CONGENITAL DISLOCATION OF THE HIP-JOINT

This relatively common condition in orthopædic practice is of great importance, in that its early recognition and treatment are attended with satisfactory results, whereas mistaken diagnosis and delay in treatment until after the first few years of life condemn the patient to serious lifelong disability.

Etiology.—This is not clear. While occasionally associated with other congenital abnormalities, in most cases the condition occurs in children otherwise well developed and healthy. Some hereditary influence has been shown to exist in about 30 per cent. of the cases. Eighty-five per cent. of the cases occur in girls, and in one-third the condition is bilateral. Normally, the acetabular articular surface, compared with that of the head of the femur, is relatively smaller in infants than in adults, covering one-third of the head at birth, and more than one-half in adult life. Violence at birth might account for some cases, but this would not explain why most cases occur in girls; it is said that girls have looser joint capsules. A history of breech presentation of more than average frequency has been noted. Presumably an intra-uterine fixation or constriction, with the thighs flexed and adducted, might predispose at least to partial displacement, or subluxation. It is thought (Thompson) that in many cases there is merely a slight subluxation at birth, rather than a complete dislocation, which becomes exaggerated and complete when walking is assumed. But complete dislocation has been detected at birth, as shown by X-ray examination, although most cases are not suspected until walking begins. On the other hand, the defect may persist throughout life merely as a subluxation, with perhaps slight shortening of the leg, or limp, skiagrams showing merely a somewhat enlarged and flattened acetabulum.

Signs and symptoms.—The first sign is usually the limp, observed

of the hip is deficient (from shortened abductor muscles and imperfect leverage), and the abdominal and spinal muscles on the same side are called into play as accessory abductors in raising the pelvis on the other side

to give the sound leg room to swing forwards. This inability to raise the

and up to 4 in. in adults. As the head of the femur is usually posterior, the pelvis is more inclined on the bad side; the anterior superior spine is forwards, and more or less on a level with the tip of the trochanter. The buttock is flattened, and the trochanter may project unduly. The head of the bone

life, adduction and flexion deformity supervenes, and the joint becomes increasingly restricted in extension, abduction, and rotation. In bilateral cases, in addition to the above signs, the pelvis is noticed to be broadened;

, and the abdo-
posterior aspect
e trunk appears
downwards in front of the thighs.
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and flexion deformity at the hip-joints, and flexion and valgum at the knees

The limp does not inconvenience a young child; but later, and more so in bilateral cases, the lameness causes discomfort on exertion, and fatigue. In adult life the increased restriction of motion and the development of advanced accommodative and adaptive changes (arthritis, knock-knee, shortening) may form a very irksome and painful disability.

Pathology.

the rim, the latter being deficient—the so-called *marginal, eccentric,* or cotyloid displacement. In infancy the displacement may be directly *upwards,* to a varied extent. This or the marginal displacement is probably the *primary condition in many cases, further posterior displacement* supervening later as the result of function. The marginal displacement may, however, never increase even throughout adult life.

Very uncommonly the original displacement is anterior, the head of the bone lying below the antero-superior spine of the ilium, where it forms a palpable, or even visible, swelling As this is a more secure position for

(anterior transposition, anterior reposition, eccentric reduction)
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patient

and on the wear and tear to which they have been subjected by attempts at function In early infancy, before any use has been made, the structure



Fig. 907.—Double congenital dislocation of hip, showing marked lordosis. (*Ernst.*)

of the joint may, except for the displacement, be absolutely normal in appearance, in which case the prognosis after early treatment is excellent; on the other hand, any degree of distortion or deficiency of the bony parts may exist from the first, with corresponding adverse prospects as to ultimate cure. Distinction must, therefore, be drawn between those changes which are (1) purely congenital; (2) accommodative—the efforts at adaptation, and the moulding in response to incorrect function; and (3) wear and tear—traumatic changes, arthritis—the lack of resistance to withstand normal strains.

The *head* of the femur may be normal, but usually it is altered in shape somewhat, and may be diminished in size. Often it is flattened on its posterior surface, where it articulates with the dorsum ilii; or it is conical or otherwise deformed. The *neck* may be normal, or short, or with lessened angle (coxa vara). Normally at birth the neck is inclined forwards about 35°. In congenital dislocation this anteversion or anterior torsion may be very exaggerated, the neck in some cases being directed almost completely forwards (i.e. in the same direction as the patella). The twist is partly in the neck and partly in the shaft. In the presence of dislocation the normal lessening of the anteversion with growth does not occur. Abnormal or exaggerated anteversion is one of the important causes of relapse after reposition of the head, which, facing the front rather than directly into the acetabulum, and in less close apposition with it, tends to ride up and lodge under the anterior superior spine (anterior transposition). It may necessitate osteotomy of the shaft to ensure the maintenance of the reduction. The *acetabulum* may be quite normal, or show any degree of poor development. The common and most important defect is deficiency of the upper posterior lip, rendering the socket broad and shallow, and permitting re-dislocation when weight-bearing is assumed after reduction. The upper lip is particularly likely to be poorly developed in those cases where the head is not completely dislocated but merely subluxated (marginal displacement). At times the acetabulum is small, or of oval or triangular shape. It is lined with hyaline cartilage. The shape and depth of the acetabulum will depend also on the age of the patient; without the stimulus of the replaced head, it becomes gradually shallower and less defined, and filled with fibro-fatty tissue. In persisting dislocation one or more false acetabula form on the dorsum ilii, from direct pressure of the head; in adult life a false upper rim may develop, due to irritation of the periosteum. The *capsule* connects the rim of the acetabulum and the base of the neck in the usual way, and is lined with synovial membrane; but it is drawn out and narrowed (hour-glass constriction) near the upper margin of the acetabulum. This constriction is occasionally so narrow as scarcely to permit the passage of the tip of the little finger, and thus passage of the head of the bone through it in ordinary manipulative reduction may be impossible. In such cases open operation and dilatation of the capsule are necessary. Over the head of the bone the capsule becomes very thick and hypertrophied in reaction to weight-bearing strain. The *ligamentum teres* is always present, and usually hypertrophied. The *long muscles* passing from the pelvis to the thigh are shortened from adaptation, but the *buttock muscles* offer no difficulty in reduction. In late cases the *os innominatum* is atrophied. Slight lateral curvature of the spine is secondary to the shortened leg, and in bilateral dislocation the lumbar spine is lordosed (and the whole pelvis tilted) to throw the body-weight over the backwardly displaced heads of the femora. In adults an accommodative knock-knee, due to fixed adduction of the hip-joint, may cause pain.



Fig. 1.—Congenital talipes equino-varus.



Fig. 2.—Bow-leg after osteoclasis.

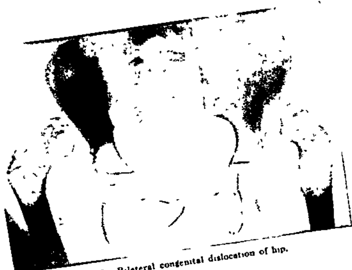


Fig. 3.—Bilateral congenital dislocation of hip.

PLATE 146.

Diagnosis.—Congenital dislocation should be recognized by the characteristic limp, or by the waddling gait when bilateral. The limp has existed since walking began, in a child who otherwise has not suffered from injury, disease, or other disability. The trochanter is raised above Nélaton's line, and the limb shortened. In infancy the joint is completely mobile, with telescopic instability. The head of the bone is absent from Scarpa's triangle and is present elsewhere—under the glutei; this distinguishes congenital dislocation from *coxa vara*, the limp of which most closely resembles it, although it is not quite so well marked. Both conditions have a raised trochanter, real shortening, and a positive Trendelenburg sign; but an early congenital hip is freely mobile, whereas in coxa vara (which is usually encountered a few years later) abduction especially, besides extension and rotation, is limited. The most difficult cases of dislocation to detect clinically are slight displacements or subluxations, wherein the limp and signs are less marked; but the skiagram solves the difficulty. *Occasionally*, as the result of *acute arthritis* in early infancy, the head of the femur is absorbed, the joint remaining perfectly mobile and simulating closely a congenital dislocation. In these cases the head cannot be palpated in the buttock, and usually slight scars exist, and a history of infection. [illegible]

Treatment and results.—Hoffa in 1890 reduced the dislocation by enlarging the acetabulum—a procedure now obsolete. Lorenz elaborated a manipulative method of Paci, which has since been essentially modified; it was much too rough and brutal. However, from custom, the "Lorenz method," and "manipulative reduction" by whatever method, remain synonymous terms. Manipulative treatment has now been extensively practised long enough (twenty to twenty-five years) to estimate its late results on the structure and function of the joint. The earlier promises have not been altogether fulfilled, and the consequent disappointment has led to modifications of the treatment, and to controversy. In the effort to standardize treatment as far as possible, and establish the most satisfactory method, much recent investigation has been made by wholesale observation of late results, and the correlation of these with the methods of treatment employed. The conclusions arrived at by the investigators for the British and American Orthopædic Associations are given below.

In general, *reduction by manipulation* is the method of choice in most cases in which reconstructive treatment is feasible. By this "bloodless method" the dislocation is reduced under anæsthesia, not by blind force but with due appreciation of the existing anatomy and mechanics. The joint is fixed in plaster for some months, in a position ensuring the greatest stability of the reduction, until mutual adaptation and support of the parts are sufficient to permit efforts at function, the degree of fixation being lessened as that of functional efforts is increased. Fostered and protected function continues for many months—the stage of exercise—after the fixation stage, until the joint becomes complete in its movements, the muscular development maximal, and the hip able to withstand the strain of weight-

the external rotation may be converted *into an internal rotation*, and vice versa; or abduction may require to be diminished, as when, by growth of the leg, the head is tending to become dislocated *anteriorly on to the pelvic*

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inverse ratio to the age of the child.

(4) Opinions differ as to the value of early *locomotion and weight-bearing* on the recently reduced hip. *Most surgeons endeavour to get* unilateral cases walking within two or four weeks after the reduction, and bilateral cases within two months; thus following Lorenz, who said that weight-bearing conduced to the development of the acetabulum. But not a few prefer not to permit
over, and
skiagrams
normally.
plaster after several months of recumbency. Under these conditions the age of walking is from two to ten months after reduction. Some surgeons protect the joint from weight-bearing for a considerable period after the child is allowed to walk about, by a calliper splint, which permits only motion and muscular development.

(5) *Open operation* as a routine treatment for reduction of dislocation is very generally condemned. It is certainly indicated in a few cases where manipulation fails. It should not be necessary in young children, and is only likely to be required at the later ages of selection. Only in carefully selected cases should it be performed after the age of six (Fairbank, who regards it as a grave operation). At the operation the obstruction to manipu-
apsule, and a narrow
o permit the head to
r-glass." Wide dis-
placement of the head of the ... socket, as seen on X-ray inspection, when seemingly a reduction has been accomplished, would suggest that the capsule had been infolded and the head had not passed through the constriction, and might call for open operation to slit the capsule. Bradford of Boston has compared the late results (ten or fifteen years after) of open operation with *those of manipulative reduction.* He had done fifty open reductions; these gave a fair percentage of *satisfactory results, but those treated by manipulation were better.* Formerly advocating open reduction, he is now converted to the manual method as a routine, and says the open method should be reserved for exceptional cases.

(6) *Anterior torsion* of the neck (anteversion) is a complication which some take seriously and others not; the former consider it a potent cause of relapse, especially if the anterior twist is more than 45°. Men of considerable experience, like Ridlon and Bradford, believe it has no significance, and do nothing to correct it, *maintaining that the deformity rectifies itself* ... stained reduction. Others, like Whitman, Sherman, and Hibbs,

of the femur before he does the reduction.

The details of the various methods of treatment must now be considered.

Manipulative reduction.—The child is anæsthetized and lies on her back; the skin should have been prepared, to diminish the risk of infection from a possible abrasion. While an assistant holds down the opposite side of the pelvis, the thigh is grasped just above the knee, flexed to about a right angle, or a little less, slightly adducted, and traction is made on the femur away from the joint; with the fingers of the other hand on the front of Scarpa's triangle, the thumb presses the trochanter and the head of the bone downwards and forwards, and, while traction in flexion is maintained, the thigh is slightly abducted; the head is felt to disappear from the buttock and rise into the joint, appearing under the fingers in Scarpa's triangle. The reduction is felt as a thud or click. The triangle becomes full instead of hollow, the hamstrings become tense, and the knee flexed. A variant of this method is to keep the fingers on the anterior superior spine, and press this backwards, in counter-pressure to the thumb on the trochanter. This manœuvre will reduce all but difficult cases. It may be necessary to diminish or increase the rotation or the flexion during the traction, according to the position of the head of the bone and the part of the posterior acetabular rim over which the head will most easily slip. In internal rotation and flexion the adductors offer little resistance (and less so as the flexion is increased), and the capsule is relaxed. In a more difficult case the surgeon may get better purchase by standing on the opposite side of the patient, when traction can be exerted in the more extremely adducted position of the flexed hip; in this case the thumb exerts counter-pressure on the anterior superior spine, and the fingers a lifting pressure on the head and neck at the back of the buttock. The thigh must be kept well adducted—almost lying across the front of the abdomen and pelvis The author has considerable confidence in the method described; it requires no preliminary stretching of the capsule and the surrounding muscles. Reduction is much more a knack than an exhibition of blind force, and the position of the head and neck of the femur in relation to the acetabulum must be appreciated throughout the manipulation. It is rarely necessary to do any circumduction manœuvre, but, if so, those of Denucé and Ridlon (*see* p. 1110) are the best, wherein the head of the bone is thrust well down behind and below the socket, and reduced from that position by a circumduction leverage action, the knee passing across the chest from the opposite shoulder towards the axilla on the same side, and thence into the right-angled Lorenz position

After reduction, the hip is re-dislocated, by adduction in flexion, to estimate the stability of the joint, and therefore the prognosis. The adductor muscles and anterior part of the capsule are gently stretched after reduction again, to increase the stability; and the thigh is brought into right-angled abduction. Usually the 90° + 90° position is adopted in neutral rotation, and the knee is included in the plaster for the first three months.

body. Reduction need not take longer than a few minutes After this time it is soon apparent whether a little extra effort is going to succeed or not; if the case is stubborn it is better to put the child back to bed, apply weight traction for three weeks, and then manipulate again. If the first manipulation fails, some surgeons fix the limb in plaster in the best position,

and complete the reduction in three weeks—an alternative to weight-traction. Bilateral cases should have both hips reduced at the same time; if one hip can be reduced and the other not, it is better to do nothing until traction has facilitated the reduction of the more resistant *joint. If reduction of a hip* is impossible after weight-traction for three weeks, open reduction should be performed when conditions of age and the degree of shortening permit. The risks of manual reduction in properly selected cases, when done with care and gentleness, are very slight; hæmatoma, extravasation, fracture of the shaft, neck, or pelvis, and paralysis are things of the past.

The plaster is retained from six to nine months, according to the stability of the joint and the age of the patient, and *is changed at three-monthly* intervals, but without alteration of position unless (1) a change from external to internal rotation be advisable, or (2) a tendency to contracture appear. The immediate result of the first reduction should be noted by skiagraphic examination, which is repeated at three-monthly intervals at the change of plasters, and subsequently. The portion of the plaster below the knee is removed after three months, unless internal rotation has to be maintained longer. There need be no hurry to diminish the length of the

carried about. Exercises to straighten the knee are begun when this joint has been freed after the removal of the first plaster. At the end of the fixation period (six to nine months) a plaster bed or night-splint is made, in which the child is bandaged, and from which it can be removed daily for massage and active exercises; this posterior splint retains the limb in the maximum distorted position procured at the first reduction, unless it be necessary to combat contracture, when the degree of *deformity is lessened. The child*

passive movements are allowed, except those producing abduction and extension (the original fixation position), but the parent or nurse can gently

stronger, full weight-bearing ...
It takes about fifteen to eighteen months to get a unilateral case walking fairly strongly, and somewhat more for a bilateral case. The plaster bed is retained at night as long as it will last—about six months. *Massage* and exercises should be continued for some time during the ambulatory stage also, as long as it seems to have any beneficial effect. Atrophy of the muscles and a tendency to eversion contracture of the hip (turning out of the foot)

should not be allowed to persist. The exercise treatment has probably more effect on the permanent function of the joint than on the anatomical result. If the stability be mistrusted, the use of a weight-relieving calliper from the time when walking is begun will protect the joint and allow the child to get about during the period necessary for the development of the socket and the head.

In the treatment of cases from 9 years of age to about 18, i.e. beyond the age of selection, it may be possible in occasional cases to effect a reduction, but the result is scarcely commensurate with the difficulty. The most that can be expected is the conversion of a posterior dislocation into an anterior transposition, which would lead to less shortening and limp, and better pelvic balance and position. Preliminary tenotomy of the adductors, and several weeks' weight-traction in recumbency, will be required. At the operation the hip is forcibly hyperextended and somewhat abducted, and held thus in a plaster spica for several months.

Operative treatment.—(1) *For reduction*.—Indications: "In patients aged 3 to 6 years that have resisted manipulation, in selected patients older than 6; and never in bilateral cases" (Fairbank). Preliminary weight-traction and manipulation to put the leg into the Lorenz position three weeks before the operation are essential. The less the direct pressure exerted on the head of the femur at the operation the better. The Smith-Petersen incision is used, which, separating the sartorius and rectus on the inner side from the tensor fasciæ femoris and gluteus medius on the outer (as in the classical anterior incision), passes back along the iliac crest for a few inches; the gluteal origins are detached from the iliac surface and turned downwards, but the periosteum is left intact. The joint is opened in front, and the isthmus notched below and dilated. Murphy's spoon lever may be necessary, but reduction of the head by manipulation causes less damage. The joint is closed, the glutei stitched back into position, and the hip fixed for six months in plaster as after manual reduction; the knee is not included in the plaster. The abduction should be reduced in three months, at the change of plaster, to prevent tendency to contracture from cicatrization.

(2) *For reconstruction of the acetabulum by bone-grafting*.—Indications: "When relapse has followed manipulative reduction and the patient is still younger than 6 years; over that age, careful selection is necessary. Patients of 3 to 6 years, and perhaps older, with marginal displacement only, should be operated upon three weeks after manipulative reduction, as the latter alone is doomed to failure" (Fairbank). In Fairbank's method the operation proceeds as for open reduction. The periosteum is incised ½ in. above the posterior margin of the acetabulum, and the periosteal flap, with flakes of bone, is reflected downwards, turned out over the capsule, and fixed there by stitches. A graft is cut from the dorsum ilii below the crest, laid on the raw periosteal flap, and also fixed to the raw edge of the acetabulum by stitches or bone-peg cut from the ilium. Albee splits the ilium above the socket, prises down the lower fragment to form a transverse roof to the acetabulum, and fills the gap thus formed with a block of autogenous bone. The hip is then put up in plaster as after reduction. The head of the femur is at first retained in position by the muscles and the fixation plaster, and not by the graft. The after-treatment is as for open reduction.

(3) *For anteversion*.—The operation can be done at any convenient site in the shaft, either before or after reduction and maintenance of the limb in the inversion position. Whitman cuts the bone in the subtrochanteric region, controlling the inversion of the upper fragment by a steel pin driven into the bone, and having its outer end incorporated in the plaster spica; with this as a

fixed point he rotates the limb sufficiently outwards, and fixes it thus until union is accomplished. The author determines the degree of correction by fixing the fragments with a Lane's plate, the bone having been divided at the mid-shaft two or three months after the reduction of the hip.

(4) *Abduction contracture.*—Rigid contracture in older cases, from too long fixation, may require either osteotomy below the trochanter or open division of the contracted capsule.

(5) *Palliative operations in unreduced late adult cases.*—Indications: (a) For pain due to progressive mechanical arthritis. The head of the bone should be excised, and the stump of the neck planted into or near the acetabulum. Fixation in plaster, with the thigh in extension and abduction, will be required for three months, after which the use of a calliper for a few months longer is indicated. (b) For adduction and flexion contracture, and knock-knee. This is met by a sub- two or three months' fixation of the limb in extension and moderate abduction.

Bifurcation operation.—For old unreduced cases Lorenz advocates his bifurcation operation. The shaft is cut in an oblique frontal plane just below the trochanter minor. The fragments are angulated inwards until they form a right angle with each other, the apex of the angulation falling into the empty socket and serving to take the body-weight. The great trochanter fragment is thus strongly adducted and the distal fragment extremely abducted

internal rotation, and

at the end of the thir

then removed at the end of the third month. Massage and re-education exercises follow; the functional results are said to be very good, in the fair flexion movement obtained and the freedom from pain.

For discussion of the **late results of manipulation** the reader is referred to Fairbank's paper (*Brit. Journ. Surg*, Vol. x, No. 37, 1922); he describes his technique and classifies results under the following headings:—

(1) *Anatomical cures.*
 (i) Where the head of the femur remains in the acetabulum, and is practically normal in size and shape.
 (ii) The head remains in the acetabulum, but is of abnormal shape —mushroomed, depressed neck (coxa vara), or partly or completely worn away (absorptive arthritis).

(2) *Anterior repositions.*
 (i) A well-shaped head exists, but is subluxated upwards and forwards, and situated at the level of the upper lip of the acetabulum, just below the anterior superior spine, with or without a recognizable socket at this site.
 (ii) The upwardly and forwardly displaced head is flattened and absorbed, and the site of the upper lip of the acetabulum also flattened and condensed.

(3) *Failures.*—Complete relapses, and failures at reduction.

Classifying his results according to *function*, Fairbank says that only occasionally do the anatomical and functional results markedly disagree. Anatomical cures of the first class give excellent function, while those of the second class are not so good. In only one quarter of the anterior repositions is the functional result good; in another quarter it is bad, and in the remaining half fair. The persisting disability in the anterior reposition cases consists in limp, sometimes pain, and shortening of about one inch Those with a positive Trendelenburg test have a worse functional result than

those without this sign. Although occasionally an anterior reposition may show a remarkably good result, Fairbank would hesitate to attribute to such cases as a class any permanent advantage over those which had not been treated. Arthritis is the inevitable fate of an untreated case; it may eventually supervene after a successful reduction, and it is questionable, therefore, whether a patient with anterior reposition will in the long run be saved from future pain and disability. In his experience the results do not warrant attempts at reduction after 9 years of age in a unilateral case, or after 6 years of age in a bilateral. Testing the stability of the joint at the time of operation enables a prognosis to be made with fair accuracy, especially in younger children.

Fairbank's percentage anatomical results at various ages (five years and upwards after reduction) are given thus:—

Unilateral			Bilateral		
Age	*Cures per cent.*	*Anterior Repositions per cent.*	*Age*	*Cures per cent.*	*Anterior Repositions per cent.*
Under 3 years	70	15	Under 3 years	46 6	33 3
3, 4, and 5	40 9	27 2	3, 4, and 5	22·7	18
6 and over	28·5	33 3	6 and over	33·3	25
All ages . .	46	25 3	All ages . .	32 6	24·4

It will be seen that in unilateral cases the percentage of cures varies inversely with the age at which reduction is accomplished, while that of anterior repositions increases. A young child has an enormous advantage over one in whom treatment has been delayed Bilateral cases are more difficult and troublesome, and they never give such good results as unilateral dislocations.

Complications.—Fairbank's series of cases well illustrates the important complications that may be met, some in the course of active treatment and others long afterwards. He gives them as follows: (1) *Pseudo-coxalgia* (osteo-chondritis deformans juvenilis). This is occasionally met with after reduction in cases where it did not exist before. The femoral head is fluffy and broken up, rather than showing the typical flattening (coxa plana). It can occur in one hip only in a bilateral case. There is generally no special history of trauma or difficulty in reduction, and the [illegible]

subacute arthritis, is occasionally noticed six to twelve months after the reduction, and may last a few weeks or a year or more; it can occur at all ages, and always subsides with rest, [illegible] eventual gross changes, thus [illegible] and more gradual onset, [illegible] (3) *Anterior displacement.* [illegible] ionally becomes dislocated forward on to the ramus of the pubis, usually in the plaster stage of treatment, but sometimes later. The misplacement is corrected by bringing the knee forward and rotating the femur inward, and applying a new plaster in this position. (4) *Ankylosis.* This may occasionally result, especially in cases reduced late. Reduction by open operation is more likely than a manipulative reduction to be followed by an apparently aseptic arthritis

leading to ankylosis. (5) *Traumatic and late redislocation.* A successfully reduced hip may be redislocated by a fall, even many years later. Relapse without apparent cause is not uncommon; it may not occur for many years, and then be partial only; probably in these cases the reduction was imperfect from the first.

End-results have also been investigated by a committee appointed by the American Orthopædic Association in 1922. They report that results vary with the structure of the dislocated joint. Moreover, the femoral head was frequently found to be misshapen in cases in which earlier X-rays show little malformation; this was especially so when much force was used in manipulation. They warn against violent methods; those from which the most perfect anatomical and functional results are to be expected seemed to the committee to be those of Ridlon of Chicago and Denucé of Bordeaux. Of the methods of reduction by machines, that carried out by means of the Hibbs table is the least objectionable.

Denucé method of manual reduction (Adams, *Journ. of Bone and Joint Surg.*, Vol. iv, No 3, July, 1922).—The only stretching before reduction is a gentle stroking of the adductors with the palm of the hand, from above downwards, no violence whatever being used. During the stretching the thigh is brought into right-angled flexion and full abduction, after which the reduction is made. The thigh is flexed on the trunk, the knee carried across to the opposite axilla, and the thigh firmly pressed down on the abdominal wall. *The thigh is then pushed along its axis towards* the hip, and the other hand is behind the head and trochanter, lifting up and *pressing the muscles in between the head and the side of the pelvis.* Then, [illegible] to its own side (still [illegible] table, and then ab- [illegible] Circumduction is [illegible] the trunk, and lying [illegible] forwards into the acetabulum. The hip is put up in plaster 90° + 90° (i.e. 90° abducted from 90° flexion), or 90° + 110° (90° abducted from 110° flexion) if unstable. The knee is included in the plaster. If the first attempt at reduction fails, it is not repeated, but a second attempt is made after three weeks' weight-traction. The knee portion of the plaster may or may not be cut off at the end of three months The plaster is left on for six months, the time not varying with the age of the patient. The posterior half of the plaster is retained for the next three weeks. The after-treatment is elaborate and consists in hot sand baths, active movements, and heliotherapy. For the first three weeks the exercises are given in the plaster, which is afterwards discarded. No passive movements are permitted. After six weeks the child is given daily salt baths, which are continued for six months, as also are the heliotherapy and exercises and the local heat. Weight-bearing is not permitted until the ossific centre of the upper epiphysis has begun to increase markedly in size—usually from three to five months after the removal of the plaster. Walking and standing are assumed gradually, and the physical treatment is continued; exercises may continue as long as two and a half years. The function is almost perfect in all the cases. No osteotomy is done for torsion. The after-care is the most important thing. This is an easy way of reducing difficult hips, and the reduction takes fifteen to twenty minutes. The hip must be almost functionally perfect before walking is permitted. X-rays show that during six months the acetabulum becomes deeper.

Ridlon method of manual reduction (*Journ. of Orthop.*

Surg., Vol. iii, No 8, Aug, 1921).—Even in difficult cases there is no preliminary stretching whatever of the muscles and capsule before the reduction is attempted—not even of the adductor muscles. The thigh is fully flexed and the head thrown low, thus avoiding the greater part of the tension on the adductor muscles and on the Y-shaped ligament. The upper end of the femur is lifted forward with the fingers at the back, while the thumb is in front of the joint. The thigh is put up in right-angled abduction and external rotation, except in such cases as seem to be more secure without rotation; the latter require a plaster below the flexed knee, but the knee is released at the end of two months to enable the child to walk; then the thigh rotates out to the neutral or middle position. The right-angled abduction position is maintained for eight months or more. All cases walk as soon as possible, unilateral cases within two weeks, and bilateral within two months. Ridlon thinks the benefit from walking in the plaster is more and more to be recommended. The best position in which to put the hip in order to retain it is the one that is found to be the most secure. The smashing up of the adductor muscles, as recommended by Lorenz, is harmful in that it takes away the support to the head of the bone, and causes anterior transpositions. Ridlon dislikes methods of reduction by machines; the traction exerted does not pull the head down behind the socket (as is falsely supposed) from which it can be manipulated into position. Traction in an abduction position is opposed by the adductor muscles, while traction in adduction causes the head of the bone to impact against the rim of the acetabulum.

In properly selected cases the percentage of hips retained in good position ought to be 50 for bilateral, 50 for anterior, 75 for superior, and 100 for posterior dislocation. Ridlon does not agree with osteotomy of the shaft for anteversion, since there are more posterior than anterior dislocations, and posterior ones ought to turn the head backwards Most dislocations are directly upwards, and there is no reason to assume a twist of the neck either way. The operation for open reduction—slitting the constriction and opening the capsular socket—is unnecessary if the child is made to walk on the replaced and the retained hip for at least six months; the operation weakens the soft parts. Manipulative reduction in the case of very

the shortening is a full inch before he replaces it; he would replace it a second or third time, but only after the shortening had reached an inch. Of unilateral cases, the left is more common than the right, and in bilateral cases the left is more liable to relapse than the right. There is no evidence of a narrowed or contracted socket, in every relapsed hip the socket has

too shallow for retention, but most of the ultimate failures are due to reducing too early, to lack of functional use during the period of retention. and neglect to replace the hip the second or third time after allowing sufficient time for shortening to take place. Hips that are still dislocated may have good function; this is so when there is good abduction and not more than 1½ in of shortening by the time the patient is fully grown. All others are failures or relapses, but some patients with 2 in. of shortening may be quite satisfied with the result.

Bradford (*Journ. of Bone and Joint Surg*, Vol. v, No. 1, Jan., 1923) is in favour of the reduction of difficult cases by *traction machines;* with such assistance successful and stable reduction has been effected in patients older than those in whom it is usually possible with manual reduction, and with comparatively *little bruising. Several patients from 12 to 15 years* of age have been successfully treated, and one of 24 years was reduced.

It is sometimes difficult to determine with certainty whether a complete reduction has been effected, or whether the head is separated from the bottom of the acetabulum by a fold of capsule. A reliable test is the tension of the hamstring tendons; another is the position of the head, which should be under the femoral artery, and not to its outer side. X-ray pictures are not wholly reliable in determining whether a complete reduction has been accomplished, *as ossification of the femoral head is always incomplete* in young children, and more so in congenital dislocation.

COXA VARA

Coxa vara is a deformity characterized by lessening of the angle formed by the neck of the femur with the shaft; it disables by causing real shortening of the leg, and producing a limp and restricted movement in the hip-joint, usually in the direction of abduction and *internal rotation. It most commonly* arises in childhood or in adolescence; injury, rickets, and the mechanical and growth factors in adolescence are the most important predisposing causes. Before the fourth or fifth year the neck of the femur is very short, but subsequently increases rapidly in length. The epiphysial line is normally more horizontal than vertical, especially in children. In a normal adult the angle formed between the neck and the shaft is 125°; in middle childhood it is greater (140°), and the inclination lessens with age The neck is directed forwards as well as inwards. The torsion is also variable, 5–20°, with an average of 12° in normal adults. Anterior torsion and upward inclination are greatest at birth. Depression of the angle may occur at the epiphysial region only (*epiphysial* coxa vara), or may extend throughout the neck (*cervical* coxa

disease, osteo-chondritis deformans juvenilis (Perthes' disease), osteo-arthritis, and osteo-myelitis. In these latter conditions the shortening and restriction of movement are due to destruction of the femoral head or of the acetabulum. Others would exclude cases of depressed neck due *to osteomalacia, osteitis deformans,* and osteitis fibrosa. In coxa vara the deformity is essentially confined to the neck (Fig. 908). True coxa vara is met with in several clinical types, which, given in the order of frequency, are—(1) adolescent, (2) infantile, (3) rickety, (4) congenital.

(1) Adolescent type (Plate 147, Fig. 1).—This is essentially a detachment or slipping of the epiphysis of the head of the femur, the separation occurring at the line of the epiphysial cartilage. It is frequently of insidious onset. From association with a history of injury, it is also known as "traumatic coxa vara" or "slipped epiphysis." It is far more frequent in boys than in girls, and very rarely bilateral, although its occasional occurrence on both sides suggests the existence of etiological factors other than mere trauma. Of the adolescent type there are four groups: (i) The deformity follows immediately upon the injury, producing a clinical picture exactly like the intracapsular fracture *of late adult age.* (ii) The



Fig. 1.—Traumatic adolescent coxa vara

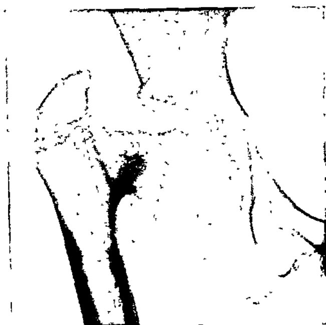


Fig 2.—Infantile coxa vara.

PLATE 147.

typical deformity is found a few months after the injury; the latter is usually trivial and causes no immediate concern, but the gradual onset of disability and deformity compels the patient to seek treatment. The epiphysis has gradually slipped. (iii) There is no history whatever of injury, even trivial. (iv) An accident occurs after a period of stiffness or pain in the joint and precipitates the separation of the epiphysis. (Elmslie.)

The relation of injury to the deformity is, therefore, variable. Trauma may cause a primary epiphysial separation, a juxta-epiphysial strain, the deformity occurring later from the effect of weight-bearing; or it may increase the tendency to deformity in predisposed subjects. Under the former conditions coxa vara is merely a fractured neck of the femur, while in the latter the deformity is a static or postural one, analogous to the other postural deformities, and similarly predisposed to by lack of resistance, ill-health,

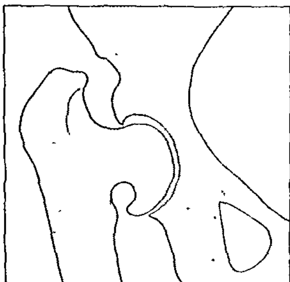


Fig. 908.—Infantile coxa vara.

slight symptoms of pain and stiffness in the hip-joint following injury in adolescents (and also in younger children). The earliest degrees of slipping of the epiphysis may be detected skiagraphically, and their recognition will prevent progress of the deformity.

In the typical deformity the separation has occurred at the epiphysial line, and the neck has slipped upwards and turned forwards, its proximal end lying at the upper margin of the head of the femur. The head of the bone remains in the acetabulum and may be rotated backwards, and, relatively, it has slipped below and behind the stump of the neck. The lower limb shows real shortening of $\frac{3}{4}$ to 1 in., the trochanter being raised to this extent above Nélaton's line. The movements of the hip-joint will depend on the stage of the deformity and the acuteness of its progress. In most

cases there is an active or progressive stage when, owing to muscular spasm, all movements may be almost completely abolished; coxa vara may then be mistaken for tuberculous disease of the hip. Although the spasmodic stiffness may last for months, it eventually disappears under treatment, and the residual restriction of movement will then be due to tension on the joint capsule, adaptive or accommodative shortening of the muscles (especially the adductors), improper position due to rotation of the head in the acetabulum, and impact of the projecting stump of the neck on the acetabular margin when abduction is attempted. Eventually, when by treatment the shortening of the soft parts has been overcome, the limb remains slightly shortened, adducted and everted. In this final stage abduction and inward rotation are very restricted, and flexion moderately so; movements in the reverse directions may be increased.

In the more active stages, besides the stiffness of the joint, there may be pain, local or radiating to the knee, or discomfort. The thigh and buttock muscles are wasted. The patient walks awkwardly, with leg everted and with a limp. The pain and stiffness are increased by over-exertion. There may be fullness and tenderness on pressure in Scarpa's triangle. The radiographic appearance is typical. Taken with the lower limb turned as much as possible inwards, the head of the femur is seen to be rotated, to face more backwards and downwards, and to be more circular in appearance, because viewed more from its distal aspect. The line of separation in the juxta-epiphysial region is ragged and fluffy—the latter more so in the more active stage. In early cases the upper corner of the stump of the neck projects opposite the border of the acetabulum; later, this is absorbed, and the upper margin of the neck is smooth and runs in a curve from the trochanter to the upper portion of the head.

In all but acute separations, union of the neck to the head occurs coincidently with the slipping; there is never non-union in the sense of a false [illegible] ion of the degree of [illegible] which weight-bearing [illegible] which deformity may progress, has been given as from two to four years, but in most cases after about twelve months' modified rest and relief of weight the neck becomes consolidated and firmly attached to the head of the femur. Pathologically, [illegible] is similar to that seen in rickets, but not so marked. It is thought by some that all these changes are the result and not the cause of the deformity; but others hold that the primary change is an infection of low-grade virulence.

Diagnosis.—Adolescent coxa has to be distinguished from *tuberculous disease of the hip-joint*, especially when marked spasm exists. In coxa vara, when the spasm has disappeared the thigh can be adducted and externally rotated, and the movements are limited only in the opposite directions. Flexion movement is, as a rule, not much impaired. There is usually no flexion deformity, external rotation is marked, and real shortening occurs early. In tuberculous disease the joint movements are limited in all directions, f[illegible] occurs late, by which [illegible] extended and everted [illegible] disease will be present.

(2) **Infantile type** (Plate 147, Fig. 2).—This variety is quite different from the adolescent. It occurs at a much younger age, most frequently

between the ages of five and eleven, in children who are apparently otherwise quite healthy and show no signs of rickets. It is as common in girls as in boys, and as frequently bilateral as unilateral. It is of insidious onset, and

The deformity is chiefly at the base or extends throughout the whole neck (cervical type), which projects transversely inwards, or inwards and downwards. Abduction is completely lost, and adduction deformity exists; in bilateral cases the knees can scarcely be separated, and, in extensive cases, scissor-leg deformity results Flexion deformity exists, of 30–40°, and complete extension is impossible Rotation is limited in both directions, and the limbs may be inverted or everted; the latter is usual, but it is never as marked as in adolescent cases. Movement is possible in the directions of adduction and flexion. The trochanters are raised above Nélaton's line, with real shortening, and there is apparent shortening, also, due to the adduction and flexion deformity. Inflammatory symptoms are absent; but

While about one-third of the cases have a distinct history of rickets in infancy, there is usually no trace of this in cases of infantile coxa vara Coxa vara may be found occasionally in association with other severe rickety deformities, [illegible] 'antile coxa vara appears in
he period of susceptibility to
e age of five it grows rapidly
be that rickets, by causing
softening and defective ossification, permits a slight and easily overlooked displacement in early life, and then the mechanical factors continue the deformity during active growth It appears probable that fracture of the neck of the femur, similar to that described above in association with the adolescent type, is not uncommon also in childhood. Whitman found a number of instances in which the neck became depressed as the result of injury; in some, progressive deformity and coxa vara resulted, the lessened angle predisposing to its occurrence. The fracture is of the neck, whereas in adolescent cases, in which the neck is well formed and strong, the injury causes a separation of the epiphysis. In some cases there is a definite history of injury, but in the majority there is none. In the infantile, as in the adolescent type, accident will not account for all the cases, especially in the bilateral condition. Non-traumatic cases have the same pathological anatomy and deformity as those resulting from fracture; therefore it is assumed that fracture is the most frequent cause of the unilateral condition, while the bilateral is the remote effect of rickets It is thought that in some cases the injury to the neck of the femur is sustained at birth.

The normal epiphysial line is almost horizontal. When the head of the femur has been displaced and the neck depressed from injury or disease, the epiphysial line becomes nearly vertical, and therefore less resistant to the body-weight. Growth occurs in a wrong direction, transversely instead

of vertically, or even from below upwards, and th
neck is gradually increased.
does not completely unite by
the neck, united only by fibrous tissue. This is a source of weakness, and leads to increase of the deformity; in later life the weak union may be completely broken through accidentally, and the head of the bone separated, with production of non-union and a false joint.

Diagnosis.—Infantile co
dislocation of the hip. Bot
resemble each other—in the
to walk with hips flexed and lumbar spine lordosed; in unilateral cases,

vara the head is found in position, and not in the buttock; the joint is movable in adduction and flexion, but rotation, abduction, and extension are very restricted; no telescopic movement is present. The diagnosis is only difficult in cases of anterior dislocation with very slight displacement upwards of the head of the bone. A skiagram will then determine.

(3) **Rickety type**.—Apart from the infantile type, which may be the later result of rickets although all signs of the general disease have disappeared, coxa vara may be found in definite association with other rickety deformities. At the age when rickets is usually active the neck is very short, largely cartilaginous, has a wide angle, and is not prone to deformity. Thus rickety coxa vara is uncommon, and only found in the worst cases—those in which the active process is continued or late. The whole neck is depressed (cervical coxa vara), the epiphysis is not displaced, and there is also an antero-external bowing of the upper part of the shaft of the femur. The symptoms are not very marked, and the condition is only one of generalized lower-limb deformity. Waddling gait and lordosis may exist, as the condition may be bilateral. Extension and abduction are limited, and the eversion range is excessive. This type is rarely treated specially, but is of importance in view of the liability to increase of deformity later as the child grows.

(4) **Congenital type**.—A few undoubted cases of congenital origin occur, and are associated with other congenital defects—with short and defective femur, and sometimes with dislocation of the hip. They are of the

Treatment.—(1) In the earliest stage the possible occurrence of the deformity must be foreseen and prevented; (2) early deformity may be prevented from increasing; and (3) advanced and disabling deformity must be corrected by operation.

Adolescent coxa vara.—The incipient condition must be suspected and recognized, especially in actively growing youths, who may be

crutches. The calliper method is preferable, and will require at least twelve

of the head of the bone with the neck should be broken down by manipulation under an anæsthetic, and the whole lower limb fixed in a long plaster spica in extreme abduction and internal rotation (Whitman's method). The deformity is corrected. After a couple of months' fixation, the plaster is removed, and massage and exercises are begun, but no weight-bearing is permitted for a year or so. An alternative method, preferred in this country, is that of weight-traction in bed, with the leg widely abducted and internally rotated, preceded or not by rectification under an anæsthetic as desired. In either case the subsequent ambulatory treatment is carried out by the "walking calliper" method; a calliper splint, besides relieving weight, can be made to check the tendency to eversion of the lower limb. In later cases, i.e. in the stage of fixed deformity, manipulative or operative interference may be necessary. The deformity in adolescent coxa vara is not usually very severe, but the limitation of abduction and of internal rotation may be sufficient to require correction. The degree of external rotation deformity varies; if it is excessive, the shaft may be cut in the subtrochanteric region or in the mid-shaft, and the leg turned in and fixed by plaster spica or metal plate When abduction must be procured also, the subtrochanteric osteotomy is best, and the position of the leg should be corrected in two planes. Limitation of abduction and flexion may be corrected by osteotomy, wedge-shaped or linear, sub- or trans-trochanteric, as seems best, but consideration must be paid to the fact that restriction may be due not altogether to the malunion but also to the adaptation of the soft parts In case of doubt, manipulation and stretching under an anæsthetic, without bone section, followed by plaster fixation and, subsequently, by passive and active movements, may sufficiently (and more rationally) correct the deformity and increase the joint movements, without resort to osteotomy; or the contracture of the soft parts may be overcome by a preliminary course of exercises, massage, weight-traction, etc. If necessary, osteotomy could be resorted to later. Intra-articular correction, at the site of deformity, by arthrotomy, with fixation of the fragments by bone-graft, by peg, or in a plaster spica, is liable to cause increased permanent stiffness of the joint, and is an operation that should not be done without much consideration. This would apply also to the removal of spurs and ridges on the neck of the femur that seem to limit abduction. Such spurs disappear in time with protected and modified use of the joint. Correction by arthrotomy is not to be recommended as a routine treatment.

Infantile coxa vara—Cases of suspected injury—infraction, strain, etc., of the neck of the femur in children—must be regarded seriously. Simple fracture of the neck in children is due to direct violence, and may be complete or greenstick. The patient may be able to walk about in a few days The condition may be mistaken for tuberculous disease, and, if overlooked, will lead to bending of the neck later. It must be treated by abduction with traction, abduction and plaster, or by protected use of the leg in a weight-relieving calliper splint. Recent deformity may be corrected under an anæsthetic. The method of forcible abduction, with fixation in plaster or in the "double abduction frame," may also be employed in the early stage of the deformity due to rickets.

Usually, however, infantile cases come for treatment only when the deformity is fixed. The deformity is much more severe than in the adolescent

form. A set deformity cannot be overcome by mechanical treatment, which serves only to stretch the soft parts Therefore, correction by open operation is indicated in all cases. The indications in infantile coxa vara are the restricted abduction and extension, the former being the more important. Rotation not usually being important in these cases, a subtrochanteric osteotomy, at the level of the trochanter minor, the wedge having the same angle as that by which the angle of the neck is less than the normal, gives a perfect anatomical and functional result; if desired, the extension range can be increased on the same bone section. The restriction of the soft parts should have been, as far as possible, overcome previously to the operation, by stretchings and exercises. This osteotomy may be undertaken even in slighter degrees of deformity, acting thus as a preventive against a possible further and more disabling condition. Fixation in plaster is required for two months.

In extreme and neglected cases, in adults, excision of the head of the femur, with implantation of the stump of the neck in the acetabulum, and [illegible]

[illegible] done in the upper part of the shaft, the apex of the lower fragment is forced against the lower part of the hip-joint as the thigh is abducted, and the lower end of the upper fragment is impacted against the side of the lower fragment, where it unites.

In all cases constitutional treatment must be instituted, as in rickets, and relief from strain, standing, and laborious occupation must be secured.

DUPUYTREN'S CONTRACTURE

Dupuytren's contracture is a *deformity of the hand in which one or more finge* [illegible] *of the paln* [illegible] *fourth or* [illegible] *first in th* [illegible] *involved.*

It is often bilateral, but rarely symmetrical; one hand may be [illegible]

or irritation from a stick or tool frequently clutched in the hand seems to be the most important exciting cause; the condition may, however, appear apart from any local irritation.

The disease is limited to the central portion of the palmar fascia, which consists of longitudinal fibres arising from the palmaris longus tendon and the annular ligament, and of transverse fibres which are exceptionally well marked just above the webs of the fingers. The processes extending into the index and little fingers are usually thinner than those to the ring and middle fingers. The longitudinal processes divide and extend forwards [illegible] antero-lateral aspects of the fingers, and are inserted into the [illegible]

and into the skin [illegible] undergo a chronic plastic inflammation that leads to much thickening and shortening, especially of the longitudinal processes. It loses its natural white and glistening appearance and becomes grey, and is also unduly

adherent to the skin. The tendons are not shortened, and there are no changes in the articular cartilages or bones except in extremely late cases. The lateral ligaments of the metacarpo-phalangeal joints may become considerably shortened.

Sym[illegible] [illegible]
in the pa [illegible]
this may [illegible]
sible, and very gradually the finger and, later, its neighbours become drawn more and more into the palm. When an attempt is made to extend the fingers, dense hard ridges appear in the lower half of the palm, in the line



Fig. 909.—Dupuytren's contracture.
(By courtesy of Mr A. H. Todd.)

of the axis of the finger and at the level of the metacarpo-phalangeal joint. Callosities may form over the palmar ridges. Occasionally only the digital part of the fascia is involved, in which case the contracture is limited to the proximal interphalangeal joint. The skin becomes very adherent to the underlying thickened fascia at the sites of the creases, and thus transversely ridged as the contracture increases. Little or no pain is complained of, except when attempts are made forcibly to straighten the fingers; but some patients speak of pains in the hand, shooting up the arm. The most serious complaint is that the deformity interferes with the free use of the hand. The progress of the deformity is slow, but it may continue until the finger is almost completely flexed into the palm.

The deformity is so characteristic that diagnosis is not difficult. It differs from the contraction of the fingers which follows *teno-synovitis* by the history and by the powerful and free action of the flexor tendons within their limited range; the flexed fingers of teno-synovitis have lost much of

their voluntary power of free flexion. *Congenital contracture* of the proximal interphalangeal joint occurs only in the little finger, and is more frequently

nodular thickening. Only those cases where the Dupuytren contracture is confined to the little finger could be confused with the congenital deformity.

Treatment.—Palliative and mechanical treatment by means of passive exercises and splints is useless, and the deformity gradually increases with age in spite of it. The only operation likely to be attended with perfect success is a complete removal, by careful dissection, of all the affected fascia. The hand should first be exsanguinated by Esmarch's bandage compression and a tourniquet. In most cases one longitudinal excision suffices, which should be in the line of an interdigital cleft, and not in that of the axis of the finger and contracted tissue. *The scar of the incision is thus*

pletely throughout its extent from the annular ligament to the digital bases. *If it is necessary to pursue the fascia into the finger, the incision can be*

tion will be most satisfactory. When the contracture is so extreme as to *make it impossible to plan an incision for the operation, the tighter* bands should be nicked in several places with a tenotome, and stretched as much as possible; this is followed by a course of splintage and daily passive *exercises, as a preliminary to radical operation, the latter being carried out* when sufficient correction has been obtained to make it possible. Mere subcutaneous division of tight bands is in itself rarely satisfactory, and the *same applies to division, as opposed to excision, through an open wound.*

After the radical excision, the wound is sewn up finely with fishing-gut, which is removed after twelve days The deformity being corrected as much

for two or three weeks, but is removed daily for massage and active exercises, which are begun after the second week. Correction greater than that obtained *immediately at the operation can be procured by straightening the splint* and fingers gradually as soon as possible after the operation; but it is better not to start movements and massage until the wound is quite beyond the irritable stage. *When the correction is sufficient the splint is omitted by* day, but is preferably retained at night for another few weeks.

VOLKMANN'S CONTRACTURE (FIG. 910)

Definition.—"A contraction of the fingers, and sometimes of the wrist, which comes on rapidly with loss of power, which is not absolute, in the forearm muscles, after a severe injury, usually in the region of the elbow-joint, generally in young children. The deformity is due to changes in the flexor muscles without injury to the peripheral nerves,

ɹused in many cases by tight bandaging and the pressure of splints" Dudgeon).

Etiology.—In nearly all recorded cases anæmia of muscle as the ɛsult of tight splinting or bandaging has been the cause. In a few exceptional cases injury or compression of the main artery of the limb has been he only cause. The most common fractures which it has complicated are —(1) separation of the lower epiphysis of the humerus; (2) fractures of he radius and ulna. Volkmann believed that the compressed musclebres died and entered into rigor mortis. It is probable that some of them ndergo this change, and this may account for the early onset of the contracture, which may come on within a few hours of the application of the plint, and too early for inflammation to be its cause. All the fibres certainly o not enter into rigor mortis, for this is incompatible with the partial recovery which we now know to be possible. It is very probable that the connective issues, lymphatics, vessels, and small nerves between the muscle-fibres are



Fig. 910.—Volkmann's contracture.

ılso damaged by the anæmia and pressure. When the splint is removed ınd the blood is allowed to enter the damaged vessels again, all the phenomena of inflammation proceed apace Complete recovery of the damaged muscles, either in function or in size, is rare A similar deformity may sometimes arise as a result of cellulitis of the forearm, as in Anderson's case, which ollowed an adder-bite. But true Volkmann's contracture is never due to cellulitis

Bristow (*Brit. Journ. Surg*, April, 1923) discusses the microscopic appearances in a case of his investigated by Greenfield, and finds them confirmatory of Volkmann's contention that the condition is a necrosis, a death of the muscle, or rigor mortis, and not a degeneration such as occurs after a peripheral nerve injury. He therefore disagrees with the opinion of Brooks, who says that the classic picture of Volkmann's ischæmic paralysis could only be explained on the basis of acute venous obstruction.

Diagnosis.—The history and the deformity are both characteristic of the disease. Volkmann pointed out the great diagnostic value of the simultaneous appearance of paralysis and contracture, because this distinguishes the condition from the contractures of the hand that may follow diseases of the nerves or central nervous system, in which paralysis long

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precedes contracture. The *main-en-griffe* of *late ulnar paralysis* simulates this deformity, but the following points clearly distinguish the two conditions: In ulnar paralysis *there is loss of use*, wasting, and want of the normal reaction to faradism in all the small *muscles of the* hand except those forming the thenar eminence and the *two outer lumbricales; and the* lean look *of the metacarpals due to wasting of the interossei* is very striking. The wrist is not flexed; there may be anæsthesia or paræsthesia *of the little* finger and the inner half of the ring finger, and trophic changes, such as glossy skin, *eczematous rash, or cyanosis of the same fingers.* There is no resemblance between paralysis of the median nerve and this contracture, but a late case of *musculo-spiral palsy* may be mistaken for it. In Volkmann's contracture, *however, there is no paralysis of the extensors of the* fingers and wrist, and the tendons of those muscles stand out prominently when voluntary but fruitless attempts at extension are made. In *musculo-spiral paralysis these muscles are paralysed, and the fingers can be extended by* means of the healthy interossei and lumbricales. Temporary lesions of the peripheral nerves may sometimes complicate Volkmann's contractures and *may confuse the diagnosis. In cases of infantile cerebral monoplegia the deformity* is usually very different; there is no clawing of the hand and the elbow is flexed, and the flexion of the fingers can be corrected by manipulation, the *contracted muscles relaxing their spasm after a few minutes.* In Volkmann's contracture supination to the full degree cannot be obtained by any means.

It should be remembered that contracture does not invariably occur in ischæmic paralysis, for continuous and prolonged use of an anterior splint may prevent any contraction of the damaged muscles.

Treatment. Prophylactic.—Tight splinting is the one great cause, and is clearly avoidable; there can be no advantage in applying a tight splint, especially soon after a fracture has been sustained, and some allowance should always be made for swelling from hæmorrhage and inflammation. Above all, the child should be seen and the limb closely observed, particularly during the first few days after the splint or bandage is applied. There must be no swelling, lividity, or want of movement of the fingers, nor obliteration of the pulse; and it should be remembered that pain is generally absent: the nerves are probably anæsthetic from severe compression. The splints should be frequently readjusted. An anterior is more dangerous than a posterior splint, and an anterior angular splint is very dangerous. A plaster splint that completely encircles the limb, or one that exerts pressure on the front of the forearm, should be avoided. When an injured elbow is put up acutely flexed (as is now the custom) in bandage only, and without a splint, the flexion must not be as extreme as possible, but a few degrees of play should be left in case the swelling in front at the angle of the joint increases.

Mechanical treatment.—Slight degrees of the deformity, if seen early, are amenable to treatment by massage and active and passive movements. These must be begun early and carried out thoroughly for a long time. Passive movements under an anæsthetic, as suggested by Volkmann, are useless, for an anæsthetic does not relax the diseased muscles. When [illegible] *movements* [illegible] lemented by [illegible] lealing with [illegible] es the wrist [illegible] d then fixes to the full, thus allowing [illegible] a splint of zinc or sheet-iron to the dorsal aspect of each finger to maintain

the extension. The metacarpo-phalangeal joints, which are then generally flexed, are frequently extended both passively and actively until, after a few days, a posterior splint can be applied from the wrist to the tips of the fingers to maintain the extension of the fingers and the metacarpo-phalangeal joints. Active and passive extension of the wrist is now performed regu-

and the hand massaged." It is more usual now to apply the splints on the flexor surfaces of the fingers, hand, and forearm; and the fingers, instead of being individually splinted, are taken together in a short plaster from the tips to the palm or wrist, the larger forearm splint being superimposed on the shorter palmar one. But the method is likely to correct the deformity completely only in mild cases.

Operative treatment.—The severest type of deformity is so resistant to correction by splints that open operation becomes necessary. The procedures advocated from time to time are—(1) tendon-lengthening; (2) shortening of the radius and ulna by excision of portions of the shaft; and (3) lengthening the flexor muscles by detaching them at their origins from the forearm bones, and allowing them to slide and re-attach themselves lower down. Operations for the relief of supposed pressure on, and constriction of, the main nerves by scar tissues are useless.

(1) *Tendon-lengthening.*—The difficulties of the operation are considerable, especially as many of the patients are little children. About thirteen shortened muscles would require attention, including the pronators. Both Littlewood and H. W. Page have published good results. The tendons are apt to become adherent to one another, and the lengthening process tends to make the muscles even weaker.

(2) *Subperiosteal excision of portions of the radius and ulna.*—This operation is better than tendon-lengthening, and is easier and more commonly employed. It was originated by Raymond Johnson. Rowlands has found it very successful. From ¾ to 1 in. of each shaft is removed in the lower part of the forearm, sufficient to give a relative lengthening of the contracted flexor tendons. The fragments are brought into end-to-end apposition, and the radius is sutured so that pronation is corrected as much as possible.

(3) *Muscle-lengthening by "sliding"*—This operation is advocated by

front of the condyle, to permit it to slide down with the muscles. The operation is not difficult.

Prognosis.—Until recently

hopeless, but at least the deformit

be expected in the worst cases. I

electricity, passive movements and, above all, voluntary movements may be required for a year or more after the operation.

BONE-GRAFTING: PHYSIOLOGICAL AND MECHANICAL PRINCIPLES

Although, from the osteogenetic point of view, the periosteum is not nearly so important as was formerly believed, it subserves a real use in the nutrition of the bone. Unnecessary removal of the periosteum should therefore be avoided in operations, because delayed union may result from the interference with the blood supply; for the same reason the muscles and

think this unimportant, as it has no effect on the proliferation of the subperiosteal osteoblasts. The endosteum is no such defined layer as the periosteum, but is merely the layer of marrow adjacent to the bone. It contains osteoblasts, and therefore is osteogenetic. When bone is transplanted autogenously, provided it is placed under conditions where at first it is

graft while at the same time laying down new bone, at first on the surfaces. Into the now osteoporotic graft new vessels enter, and osteoblasts with them, and absorption and re-formation take place in the depth of the graft. For about eight weeks absorption outstrips the re-formation, but after that, if the graft is made to sustain strain and exercise function, the reconstruction outstrips absorption. To undertake function it is necessary that the graft shall have been fixed firmly to the rest of the bone. If, on the other hand, the graft is put to no use, as when it is buried in the depths of muscles, absorption predominates over reconstruction, and the graft gradually disappears. The breaking up of the graft into pieces, with the idea of securing viability of a greater number of osteoblasts, has no advantage. Homogenous grafts, those taken from another animal of the same species, are at times successful, but viability and capacity for proliferation are more uncertain than in the autogenous. Possibly the success of homogenous grafts in man partly depends upon whether host and donor belong to the

gap, autogenous bone is to be preferred. When the of continuity and the graft is merely required as a peg, there is scarcely any advantage in using living bone, as dead bone can be prepared in advance so easily. An autogenous graft, merely in contact with *living bone* but

taking no strain or function, will atrophy and disappear. A single graft of any kind is always to be preferred to one that is broken up in pieces: some of the fragments may die;
fragments like this do not tend
expected, and powdered bone is
broken will often reunite with

expose the endosteum to a better blood supply.

Efforts have been made to transplant joints in animals with some success. The changes in the bone tissue were similar to those described above as occurring in the length of the shaft; in the articular cartilage the superficial cells lived while the deeper necrosed, and the cartilage remained active and lived. The epiphysial cartilage seems to have been destroyed.

Ivory, as medullary pegs, plates, and screws, has been used extensively, as have also plates and screws made of bone, the latter particularly in the operative treatment of recent fractures instead of metal plates and screws. The ivory and the dead bone behave in much the same way; in a clean wound they become firmly attached to and incorporated with the host-bone, but are eventually absorbed if not too massive. If the wound is septic, the ivory or dead bone does not become attached, but later has to be removed as a sequestrum. In some cases ivory pegs seem to disappear completely in a few months, while in others they remain unchanged for years. Massive ivory grafts have been used to replace half the lower end of the humerus, or half the lower jaw. In the beginning the wound may heal well, but after a long interval the foreign substance is liable to produce suppuration and require removal. Konig replaced half a mandible with ivory; it became firmly attached to the other half of the jaw, and articulated at the temporo-mandibular joint, and was still satisfactory at the end of two years. (Hey Groves.)

Technique of bone-grafting.—Abundant clinical and experimental evidence has proved that mechanical success in bone-grafting, by

fixation and apposition of the graft can be procured in several mechanical ways At one time absorbable sutures, passed around graft and bone together, or drilled through both, were employed, this method being particularly applicable when the extent of contact was not very great. But no such absorbable suture can give a joint in which there is no play whatever, and so, in general, this method is not advocated. Some have strongly advocated the free use of bolts and screws, or wires, to fix the graft to the main fragments, but the arguments that would apply against Lane's plates and screws as a universal method in the operative treatment of fractures would apply even more in bone-grafting cases. Undoubtedly, the best fixation of all is obtained by accurate joinery, in which, by impaction, dovetailing, and end-strain on the graft, the fragments and graft lock themselves into one solid whole. A graft can be

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inserted into a bone either by *inlaying* into a groove in the side of a bone, substituting a portion of the compact tissue, or as a central peg within the medullary canal—the *intramedullary* method. Most surgeons favour the inlay method, but the author, in an extensive series of cases, has with complete satisfaction used the intramedullary method whenever possible since 1916. The medullary graft is stronger than the inlay, and does not necessitate so much exposure of the bone, and no sutures are necessary. Where the bone is v
the medullary canal
method can be empl
the humerus and the
fellow bone is intact
end, the other end requiring slotting. A cortical or inlay graft requires more exposure of bone. It is of especial use where a gap has to be bridged, and where it is desirable, as in a shortened radius with deflected hand, to restore the original length of the bone. An inlay graft may require suturing, to prevent it from springing out, and needs to be splinted more carefully than an intramedullary graft. The result of medullary grafting in a case of malunited Pott's fracture is illustrated in Plate 148. Other methods, less often employed, need only be mentioned. These are an autogenous graft fashioned as a plate, screwed on to the outer surfaces of the fragments; and fixation by
the graft within
blocking the me
has no foundatic
of the original
portion, being retained rigidly to it by suture, or by dovetailing into the ends of the main fragments.

When any considerable length of autogenous graft is required, it is usually cut from the easily accessible subcutaneous surface of the tibia. A piece 10 or 11 in. long by $\frac{3}{4}$ in. wide and $\frac{1}{2}$ in. thick may be removed if required. Short irregular or thick pieces may be taken from the crest of the ilium. Ribs are of n
are liable to l
ing must be
tected and assisted, must be instituted, as the building up of the graft is favoured by the assumption of function, whereas prolonged immobilization hinders its osteogenetic reconstruction.

An ununited fracture (*see* p. 806) is often best treated by bone-grafting after correction of deformity. The reuniting of severed nerves and operations on tendons are usually postponed until the bone has been mended, except in the case of the nerves of the upper arm, the union of which, after

actures grafting
is
ies, such as wire
or
grafts, and are
not wholly appropriated as by metal. But each has its indications, and only metal can safely withstand the strain of a complete operative correction of an old-standing malunion. Other broad indications are reconstruction and stabilization of joints, and the correction and prevention of deformities. Arthrodesis, or artificial ankylosis, eradicates joints that are unduly mobile or flail, either from want of muscular control, as in infantile paralysis, or



Fig. 1 —Malunited Pott's fracture before grafting



Fig 2.—Same case as Fig 1, showing results of intra-medullary grafting done 14 months after the injury.

PLATE 148.

from loss of bone-ends, as in destructive disease or extensive injury, or when such movement as exists is too limited and painful to be worth preserving. A graft across the bone-ends, provided that the joint is completely excised, forms the most certain method of procuring bony ankylosis and maintaining accurate apposition. Spinal grafting is a similar application—to rest the diseased area and prevent deformity in tuberculosis, to prevent deformity in paralytic scoliosis; and to alleviate pain in traumatic or infective arthritis. Joint-ends may require reconstruction to prevent dislocation and flailness, as in congenital dislocation of the hip with deficient acetabular margin, and in pathological and traumatic dislocations (e.g. from gunshot wound) of the hip, shoulder, and elbow when there is loss of one or other bone-end. After the eradication of bone disease—tuberculous diaphysitis, and benign tumours and cysts—the shaft may be immediately reconstructed along the lines laid down for the treatment of non-union. Bone-grafting has also been employed to prevent slipping of tendons, by exaggerating the bony prominence acting as the pulley over which the tendon moves, as in recurrent dislocation of the patella, where the groove on the front of the femur is augmented (Albee), and in dislocation of the peronei tendons, by increasing the prominence of the external malleolus. In con-

use of an appliance.

MANIPULATIVE SURGERY ("BONESETTING")

We are here concerned not with gross deformities due to acute injuries but with subluxations and minor displacements, and some other affections which cause painful or stiff joints—conditions in which the disability is out of proportion to the structural change, and in which the lay practitioner, with his methods of mobilization and activity, frequently meets with success. Much attention has been devoted to this branch of the work by Robert Jones, whose views are here embodied.

If we exclude the real intrinsic fibrous or bony ankyloses due to gross arthritis, with destruction of articular ends, in which manipulation only corrects the position but does not restore movement, and if we omit also cases due to extrinsic causes of limitation, such as severe and old-standing contractures of soft parts, there remain many stiff joints in which forced passive movements, with or without anæsthetic, followed immediately by
n and to rapid restoration of joint
ess include trauma and arthritis;
iorrhage, or damage to synovial
, may be associated with fracture
with some internal derangement, e.g. a displaced intra-articular cartilage or loose body. Among the extra-articular causes of stiffness are the adhesions and contractures that may follow damage to capsule, ligaments, muscular origins and insertions, rupture of muscle-fibres, or extravasations into tendon sheaths; or there may be accommodative or adaptive shortening of the muscles and muscle sheaths, as in the stiff knee that sometimes remains after fracture of the femur. This adaptive shortening may follow prolonged fixation of even healthy adult joints. The problem before the surgeon is when to move and when to rest a stiff or painful joint. Undoubtedly, in the past the inactive process has been too much favoured, for fear of lighting up any inflammatory or infective process. Rest will not increase mobility of tissues nor lead to development of muscles, however long continued, whereas a single well-directed passive

movement followed by attempts at active movements will not often cause irreparable injury to the joint. The rule, "When in doubt, move," would lead to more successes than failures. Certainly, an arthritic joint requires rest as the preliminary treatment. It is sometimes *difficult to determine* whether stiffness is due to early arthritis or to adhesions. As a rule, in a painful joint, *limitation of movement in all directions implies the presence of arthritis*; whereas a free movement in some directions, or perhaps in all, suggests freedom from arthritis. In early cases the rigidity is due to protective muscular spasm, and must be tested for without an anæsthetic; in late cases contractures of muscles will have occurred secondarily. The occurrence of adhesions should be prevented by resort to early movements. Early movements should be *painless, and active, done by the patient himself*, rather than passive. When the joint has not been directly injured, active movements may be allowed at once, as far as the patient can do them painlessly, care being taken in the case of fractures to avoid movement of the fragments. If the joint itself has been injured, active movements should begin when the acute symptoms cease—when the swelling is disappearing and the acute pain and tenderness are gone. Early passive movement is contra-indicated, but the patient will not harm himself by his own voluntary active efforts. *Passive movements are helpful after a couple of weeks or so*, when the damaged part may be considered to have healed or united, but should consist of a single movement in each direction, the range of which is increased daily if possible.

Full anæsthesia is necessary when the adhesions are firm and the patient is muscular, but gas has an advantage in that active exercises can begin immediately after. Before any manipulation under anæsthetic, it is very [illegible] the joint subjected to baking or to some other heat [illegible] sually [illegible] ment; [illegible] es by manipulations repeated *after an interval of a week or two*, the joint being exercised meanwhile. It is necessary to stretch the joint through its range [illegible] stretchings at the time of manœuvre are [illegible] joint surfaces. Immediate early active and passive movements [illegible] desirable, unless there be considerable reaction, but the latter is evidence that the manipulation [illegible] overdone. If after manipulation the range of movement *becomes* [illegible] ective or the manipulation was not [illegible] manipulation, and is of no moment; [illegible] are toned up by active exercises. Diminished mobility *after use and exercise* calls for rest, but increased mobility indicates exercise, even though pain exist. Pain rapidly passing off with the daily exercise is of no importance, but if protracted it probably means reaction and increased stiffness, and therefore rest is indicated. In cases where the manipulation is attended with the *cracking and snapping* of adhesions, the prognosis is more favourable than in those where the resistance is only overcome by gradual stretching; in the latter the joint should be retained in a correct position for a few days to overcome the resistance *of contracted soft tissues*, before exercises are begun.

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